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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

MBA PROFESSIONAL REPORT

**Commander Naval Air Forces (CNAF) Aircraft Operations
Maintenance (AOM): An Examination of Effectiveness in Maintaining
and Operating an Aging Aircraft Fleet**

**By: Kenny K. Chase
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 December 2006**

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**COMMANDER NAVAL AIR FORCES (CNAF) AIRCRAFT OPERATIONS
MAINTENANCE (AOM): AN EXAMINATION OF EFFECTIVENESS IN
MAINTAINING AND OPERATING AN AGING AIRCRAFT FLEET**

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COMMANDER NAVAL AIR FORCES (CNAF) AIRCRAFT OPERATIONS MAINTENANCE (AOM): AN EXAMINATION OF EFFECTIVENESS IN MAINTAINING AND OPERATING AN AGING AIRCRAFT FLEET

ABSTRACT

Naval aviation serves as a vital component of many air and ground task organized forces vying for a share of the Department of Defense (DoD) budget. The decisions in the 1990s to reduce purchases of new equipment left the Navy with aging fleets of aircraft that are increasingly expensive to maintain. This situation coupled with the cost of the Global War on Terror has created a cycle in which more funds are spent maintaining older equipment at the expense of new purchases. This has lead to still older equipment and higher maintenance costs. The increases in the costs of operating and maintaining aging military equipment have created a budgetary crisis in the Department of Defense.

The Commander Naval Air Forces (CNAF), Commander, Naval Air Force, U.S. Pacific Fleet (COMNAVAIRPAC), and Commander, Naval Air Force, U.S. Atlantic Fleet (COMNAVAIRLANT), face the great challenge of effectively vying for their share of the 37 percent of the DoD budget that pays for the day-to-day costs of Operation and Maintenance (O&M) (CBO, 1997). Precisely identifying budgeting and costs for sustaining Aircraft Operations Maintenance (AOM) of the Navy's aging fleet of aircraft is vital to preserving an essential component of current war fighting doctrine. Unfortunately, establishing the association between age and costs is complex. Costs are likely to be affected by an aircraft's age, component technology, the number of flight hours, manner in which the aircraft is flown, and the resources devoted to maintenance. Therefore, to better identify costs and maintenance trends of value to Naval aviation, the cost drivers for AOM should be investigated.

The purpose of this study is to analyze the effectiveness of the aircraft maintenance process in conjunction with actions to remove impediments to non-deployed aviation readiness. The methodology for the study involves an analysis of specific

changes in training of personnel, equipping depots, executing maintenance programs, and better utilizing infrastructure, and an assessment of the results of these changes.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym	Definition
AGSAG	Activity Group/Sub-Activity Group
AIMD	Aircraft Intermediate Maintenance Department
AMSR	Aviation Maintenance Supply Readiness
AOM	Aircraft Operations Maintenance
APU	Auxiliary Power Unit
AVDLR	Aviation Depot Level Repairable
AWM	Awaiting Maintenance
AWP	Awaiting Parts
BCA	Business Case Analysis
BCM	Beyond Capability of Maintenance
BRAC	Base Realignment and Closure
CAVTS	Cost Adjustment and Visibility Tracking System
CBO	Congressional Budget Office
CFT	Cross Functional Team
CITE	Center of Industrial and Technical Excellence
CLS	Contractor Logistics Support
CNA	Center for Naval Analyses
CNAF	Commander, Naval Air Forces
CNO	Chief of Naval Operations
COCOM	Combatant Commander
COE	Center of Excellence
COMNAVAIRLANT	Commander, Naval Air Force, U.S. Atlantic Fleet
COMNAVAIRPAC	Commander, Naval Air Force, U.S. Pacific Fleet
CPI	Continuous Process Improvement
DBR	Drum Buffer Rope
DD	Defense Depots
DLA	Defense Logistics Agency
DLH	Direct Labor Hours
DMADV	Define, Measure, Analyze, Design, Verify
DMAIC	Define, Measure, Assess, Improve, Control
DoD	Department of Defense
DoN	Department of the Navy
DRMO	Defense Reutilization and Marketing Office
DSC	Defense Supply Center
ECP	Engineering Change Proposal
FAR	Federal Acquisition Regulation
FFP	Firm Fixed Price
FHCR	Flight Hour Cost Report
FHP	Flight Hour Program
FMB	Office of Budget

FISC	Fleet Industrial Supply Center
FMC	Full Mission Capable
FMS	Foreign Military Sales
FRC	Fleet Readiness Center
FRP	Fleet Response Plan
GAO	General Accounting Office
IMA	Intermediate Maintenance Activity/Agency
IPT	Integrated Product Team
JCS	Joint Chiefs of Staff
JCSG	Joint Cross-Service Group
JIT	Just In Time
LSS	Lean Six Sigma
MALS	Marine Aviation Logistics Squadron
MMP	Monthly Maintenance Plan
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MTBF	Mean Time Between Failures
MTBM	Mean Time Between Maintenance
MTTR	Mean Time To Repair
NAB	Naval Amphibious Base
NADEP	Naval Aviation Depot
NAE	Naval Aviation Enterprise
NALCOMIS	Naval Aviation Logistics Command Management Information System
NAMSR	Naval Aviation Maintenance Subsystem Reporting Plus
NAPPI	Naval Aviation Pilot Production Improvement
NAS	Naval Air Station
NAVAIR	Naval Air Systems Command
NAVICP	Naval Inventory Control Point
NAVRIIP	Naval Aviation Readiness Integrated Improvement Program
NAVSEA	Naval Sea Systems Command
NAVSUP	Naval Supply Systems Command
NRFI	Not Ready For Issue
NAWCAD LKE	Naval Air Warfare Center Aircraft Division Lakehurst
NWCF	Navy Working Capital Fund
OEM	Original Equipment Manufacturer
OFC	Operational Functional Category
O&M	Operations and Maintenance
OMA	Organizational Maintenance Activity
OMB	Office of Management and Budget
OP	Operations Plan
OPNAV	Office of the Chief of Naval Operations
OSD	Office of the Secretary of Defense
PBA	Performance Based Agreements

PBL	Performance Based Logistics
PHST	Packaging Handling Storage Transportation
PM	Program Manager
PMA	Program Manager Air
POM	Program Objective Memorandum
PSI	Product Support Integrator
RFI	Ready for Issue
RFT	Ready for Tasking
RMC	Regional Maintenance Center
ROI	Return on Investment
S&S JCSG	Supply and Storage Joint Cross-Service Group
SIC	Special Interest Category
SOO	Statement of Objectives
SOW	Statement of Work
SPAWAR	Space and Naval Warfare Systems Command
SRA	Shop Replaceable Assemblies
SYSCOM	Systems Command
T/M/S	Type/Model/Series
TOC	Theory of Constraints
TRR	Time to Reliably Replenish
USD (AT&L)	Under Secretary of Defense, Acquisitions Technology & Logistics
WIP	Work in Progress
WRA	Weapon Replaceable Assemblies

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I. INTRODUCTION

A. PURPOSE

The intent of this study is to serve a dual purpose. First, the report will provide a summarization of the funding elements of Intermediate Maintenance Activity (IMA)/Organizational Maintenance Activity (OMA). Identifying the funding formulation and the current cost trends of maintaining an aging fleet of aircraft will emphasize the need for strategic positioning with effective programs and financial plans to meet the Chief of Naval Operations' (CNO) readiness goals. Second, the research will provide an analysis of current and future maintenance programs designed to build efficiency and save money. Specifically, the study entails an examination of the Radar Center of Excellence (COE) at Naval Air Station (NAS) Lemoore as it relates to cost-wise readiness and Enterprise *AIRSpeed*. These programs highlight changes following the Navy's attempt at transformation to a more efficient and lean aircraft maintenance process model. The study aims to provide insight into whether these changes have resulted in an improvement in program efficiency and achievement of cost savings in Aircraft Operations Maintenance (AOM) expense accounts.

B. RESEARCH QUESTIONS

The body of the project addresses the following questions:

1. Primary Research Question

To what degree of effectiveness is the Navy presently able to meet its aircraft maintenance requirements with its current resources?

2. Secondary Research Questions

a. What specific changes, if any, have been made to aircraft maintenance process models to improve efficiency and effectiveness of current programs?

b. If changes have been made, have they produced any significant and measurable improvements in readiness and cost?

c. How will future budgeting affect aircraft maintenance processes?

C. SCOPE AND METHODOLOGY

To meet our objectives, we reviewed the current processes and future initiatives associated with AOM. To accomplish this review, we selected to visit Commander Naval Air Forces; NAS North Island and NAS Lemoore. While at these commands we were able to conduct interviews with budget analysts, aircraft maintenance policy officers, and *AIRSpeed* officers. In addition, we also reviewed data used by aircraft maintenance policy officers and *AIRSpeed* officers to determine resource requirements essential in defining maintenance capabilities. In order to properly analyze the this data, we also reviewed Joint Chiefs of Staff (JCS) studies, Base Realignment and Closure (BRAC) reports, General Accounting Office (GAO) reports, public laws pertaining to Department of Defense (DoD) maintenance, Naval Aviation Maintenance Subsystem Reporting Plus (NAMSAR Plus) maintenance and material data, and Fiscal Year 2003 – Fiscal Year 2004 (FY03-FY04) Execution Operations Plan-20s (OP-20), in order to (1) understand the ability of gaining depots to absorb additional work loads; and (2) understand legislative actions mandating specific criteria relating to maintenance initiatives.

D. ORGANIZATION OF STUDY

The study contains five chapters.

Chapter I provides an introduction to the study that includes a section on purpose, scope and methodology, and a statement of primary and secondary research questions.

Chapter II provides an overview of the budgeting and funding elements relating to AOM expense accounts. Specific sections include discussion of the Operational Functional Category-50 (OFC-50) account, its funding structure, and budgeting process. This chapter will also consider Naval Aviation's paradigm shift from "readiness at any cost" to "cost-wise readiness" (Malone, 2004).

Chapter III provides a more detailed examination of cost-wise readiness and its relationship to Enterprise *AIRSpeed* (CNAF, 2005). This chapter discusses goals and vision, context and perspectives, functional performance, initiatives considered and key assumptions.

Chapter IV provides an examination of the Radar COE at NAS Lemoore. This chapter discusses the functional process descriptions, performance impacts and metrics, and operational cost savings associated with the COE. This chapter examines the impact of the COE on future aviation maintenance innovations since it was established as an offshoot of cost-wise readiness standards.

Chapter V provides conclusions, a summary of answers to the primary and secondary research questions, and recommendations to improve the Navy's re-sourcing and management of AOM expense accounts, and suggested areas of further study.

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II. BACKGROUND

A. OVERVIEW

Prior to 11 September 2001, we lived in a post-Cold War world where the U.S. Navy had changed its doctrine and reduced its size. We are now living in a world engulfed in a War on Terror where our armed forces, more specifically the U.S. Navy, have seen an increase in worldwide operations. According to the Congressional Budget Office (CBO), the Department of the Navy's (DoN) budget has shrunk by about 35 percent since 1985 (adjusting for inflation) (CBO, 2001). In light of these facts, the Navy has found it increasingly difficult to modernize the Fleet and maintain a level of operational readiness that supports the projection of overseas presence as in the past.

Naval aviation serves as a vital component of many air and ground task organized forces vying for a share of the DoD budget. Decisions in the 1990s to reduce purchases of new equipment left the Navy with aging fleets of aircraft that are increasingly expensive to maintain. This situation coupled with the cost of the War on Terror has created a cycle in which more funds are spent maintaining older equipment at the expense of new purchases and planned modernization of the Fleet. This has lead to still older equipment and higher maintenance costs. The increases in the costs of operating and maintaining aging military equipment have created a budgetary crisis in the DoD and the DoN.

The Commander Naval Air Forces (CNAF), Commander, Naval Air Force, U.S. Pacific Fleet (COMNAVAIRPAC), and Commander, Naval Air Force, U.S. Atlantic Fleet (COMNAVAIRLANT), face the great challenge of effectively vying for their share of the 37 percent of the DoD budget that pays for the day-to-day costs of Operation and Maintenance (O&M) (CBO, 2005). Precisely identifying budgeting and costs for sustaining AOM of the Navy's aging fleet of aircraft is vital to preserving an essential component of current war fighting doctrine. Unfortunately, establishing the association between age and costs is complex. Costs are affected by the age and types of components of the aircraft, the number of hours managed in the Flight Hour Program (FHP), the manner in which the aircraft is flown, and the resources devoted to

maintaining the aircraft over time. Additionally, high operation tempos have led to the need to “cross deck” deployed assets and the deferral of intermediate and depot maintenance. Deferred maintenance has the potential to increase maintenance actions and support costs.

B. AIRCRAFT DEPOT MAINTENANCE

Equipment maintenance concepts in DoD use three levels of maintenance:

Organizational maintenance (O-level) consists of the on-equipment tasks necessary for day-to-day operation, including inspection and servicing and remove-and-replace operations for failed components (includes so-called line replaceable units or weapon replaceable assemblies).

Intermediate maintenance (I-level) consists of off-equipment repair capabilities possessed by operating units and in-theater sustainment organizations. These capabilities can be quite extensive, and include remove-and-replace operations for subcomponents of line replaceable units (so-called shop replaceable units or assemblies), local manufacture, and other repair capabilities.

Depot maintenance (D-level) consists of all repairs beyond the capabilities of the operating units, including rebuild, overhaul, and extensive modification of equipment platforms, systems, and subsystems. The depot level is the ultimate source of repair (OSD, 2004).

Depot maintenance sustains equipment throughout its life cycle through the performance of major repairs, calibrations, overhaul, complete rebuild of an entire weapon system (e.g., aircraft, ship, or truck), complete rebuild of an assembly (e.g., engine), and the complete rebuild of subassemblies (e.g., engine blades). Depot maintenance also encompasses the installation of modifications to extend the operational life of weapon systems or improve their performance. Corrosion control, structural rehabilitation and supporting lower level maintenance activities with overflow maintenance are also critical activities at maintenance depots.

The Aircraft Depot Maintenance program sustains AOM by providing airframe, engine, and component rework to meet established CNO readiness goals. The DoD is required by Title 10 U.S.C. Section 2464 to perform organic maintenance on its materiel. DoD Directive 4151.18 states that “[m]aintenance programs are structured for meeting

readiness and sustainability objectives (including mobilization and surge capabilities) of national defense strategic and contingency requirements." These national requirements include Naval air power as a major component. Recurring maintenance is required on all U.S. Navy aircraft to keep them mission-ready and safe for continuous operations in support of the defense of the nation.

The need for Naval Aviation is outlined in documents such as *Naval Aviation Vision 2020* and *Sea Power 21*. They embody the collaboration of Fleet officers, planners, and Naval Air Systems Command (NAVAIR) subject matter experts. More than half a dozen technology roadmaps depict how Naval Aviation will support the Navy's over-arching transformation in projecting air support throughout the world.

The Navy has Title 10 responsibility for the maintenance of its aircraft and the continuous review of its maintenance procedures and models to increase its efficiency. Title 10 U.S.C. Section 2464 "provides that DoD activities maintain a logistics capability sufficient to ensure technical competence and resources necessary for an effective and timely response to a mobilization or other national defense emergency" (GAO-93-13, 1993). In addition, activities are limited in the use of contracting services for the maintenance of mission essential equipment under Office of Management and Budget (OMB) Circular A-76 (GAO-93-13, 1993). Such practices determine workload requirements and performance measurement. The NAVAIR Depot Maintenance program allows Naval aircraft to operate in a high degree of readiness and has contributed greatly to the operational success of the Navy.

The management of AOM is a high priority within the Navy, where funds are exclusively targeted for it using the Naval Aviation Maintenance and Material Management System. The Office of the Secretary of Defense (OSD); the Assistant Secretary of the Navy, Financial Management and Comptroller, Office of Budget Division (FMB); and Fleet budget offices conducts mid-year reviews to ensure that funds are being properly executed within the program (OSD, 2006). Within the Department of the Navy, FMB formulates the Navy budget which includes supplemental requests, reprogramming, monitoring budget execution, and reporting on budget execution to the Under Secretary of the Department of Defense, Comptroller (OSD, 2006). All funds

used for AOM are contained within specific sub-activity groups which will be discussed later on. The importance of AOM is further highlighted by the fact that congressional approval is required before adjusting funds of \$15 million or greater from this fund code.

Each aircraft type-model-series (T/M/S) has a tailored maintenance program designed to keep it in a high state of material readiness. The Navy uses a Reliability Centered Maintenance method to identify maintenance required to maintain aircraft at a minimal cost. This method is a commonly used procedure to analyze the equipment found in a specific process. It helps create a maintenance interval and schedule based on the reliability of that equipment. Today's need for economic efficiency and reduction of downtime requires that preventative maintenance be implemented based on important factors such as mean time to repair (MTTR) and mean time between failures (MTBF). The Navy however uses the metrics of output of airframes and engines necessary to meet readiness requirements. Performance metrics are reported in the Navy FY06 budget. The Navy's goal is to have 73% of its aircraft Full Mission Capable (FMC) (OPNAVINST 4790.2J, 2005). The FMC rate refers to the availability of aircraft to carry out their assigned mission (GAO-03-300, 2003).

Long-term estimates of maintenance actions are listed out to the year 2014 in the Program Objective Memorandum (POM). The Navy budget planning documents contain estimated airframe and engine induction requirements for future years to attempt to meet 100% of the maintenance requirements for deployed squadrons and achieve 90% or better fill rates for parts and component requirements. The outlying projections indicate the estimated pieces needing induction into maintenance to support CNO readiness goals. The Navy bases these estimates on previous year's performance measures, age of equipment, and inflation adjustments. Funding actions for specific aircraft maintenance actions can be tracked through the review of monthly readiness reports and supporting budget planning documents that support the President's budget request.

C. FUNDING STRUCTURE

The DoN publishes a planning document in the form of the OP-20 to establish the annual flying hours (MCO 3125.1A, 2005). The OP-20 is used for FHP O&M funding

and fleet planning. The funds are then allocated to Activity Group/Sub-Activity Group (AGSAG). The AGSAG is a four-character alphanumeric code used in the appropriations process to define and classify resources by specific purpose.

- AGSAG 1A1A – 1A Air Operations, 1A Mission and other Flight Operations, which includes Tactical Aircraft operations and Fleet Air Support (FAS) operations.
- AGSAG 1A2A – 1A Air Operations, 2A Fleet Air Training or Fleet Refresher Squadron trains new pilots or transitioning pilots.

Both 1A1A and 1A2A are broken down into OFC to provide specific use of funds. This study will refer to elements of OFC-50, IMA/OMA funding. Within the OFC-50 there are several performance metrics that form the basis for the budgeting of funding elements corresponding to AOM expense accounts assigned a Special Interest Category (SIC) designation to each Fund Code as follows: 7L Consumables and 9S Aviation Depot Level Repairable (AVDLR).

Under Fund Code 7L, consumables are inexpensive items used to support flight operations. Used for both O-Level and I-Level maintenance functions, funding occurs for the acquisition of consumable parts, materials, tools, lubricants and services to repair aircraft, support equipment, or aeronautical components. The OP-20 identifies the costs for consumables under the SIC *FM* and is part of the total FHP cost per hour calculation.

An AVDLR is a high dollar item that requires repair at the D-Level and is identified in monthly Budget Operational Reports (BOR) under Fund Code 9S. The AN/APG-65/73 F-18 radar, “the [number] 2 degrader on the top ten” list at Aircraft Intermediate Maintenance Department (AIMD) NAS Lemoore, is an example of an AVDLR that represents the most significant dollar investment in accomplishing repairs and improved management of these components to increased readiness of F-18 squadrons (Kemna, 2005). The Navy Working Capital Fund (NWCF) funds the repair of an AVDLR. While the end user will initiate an AVDLR demand, the local IMA will

determine whether the request will result in an AVDLR NWCF charge. Consequently, the end user or local IMA retains control of the AVDLR funds and corresponding accounting responsibilities. The OP-20 identifies an AVDLR under SIC *FA* and is part of the total FHP cost per hour calculation.

Contract maintenance is the outsourcing of aircraft maintenance and support services to civilian or NWCF activities to support the end user. Costs include fixed and variable cost estimates. Program fixed costs obligate funds in spite of hours flown, while projected squadron flight hours determine variable costs. Contract maintenance is identified as SIC *FW* on the OP-20 and is part of the cost per hour calculation.

1. Budgeting and the Budget Process

OFC-50 expenses account for 80 percent (*Maintenance Consumables + Contract Maintenance + Repairables*) of the direct flight hour costs to OP-20 as depicted in Figure 1. Furthermore, the percentages in Figure 1 represent the average for the entire Fleet and would shift dramatically for different aircraft T/M/S. The inherent uncertainty of maintenance costs, however, has prevented an accurate estimation of projected costs, which results in recurring funding shortfalls and the need for inventive revenue generating activities. Each program carries a specific pricing model designed to obtain the best budget estimate using the most ideal variables.

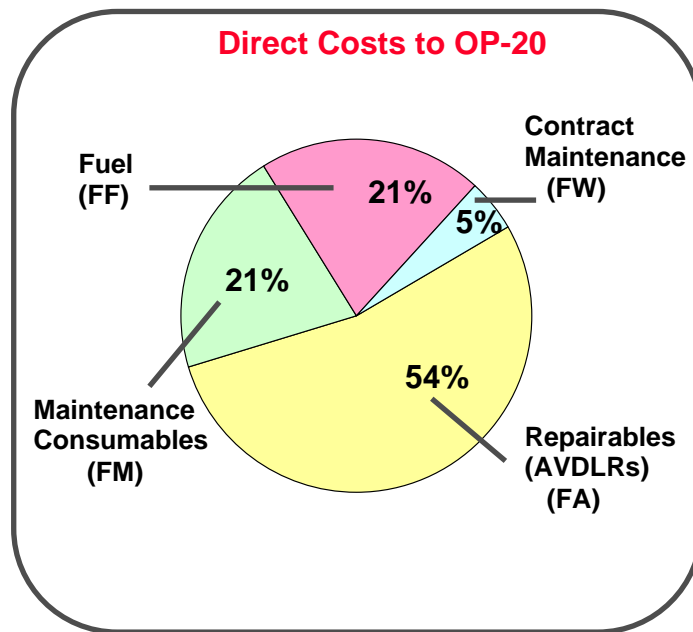


Figure 1. Diagram of OP-20 Direct Costs.
Source: OPNAV 43 Flight Hour Program Brief May 2005.

The AVDLR pricing model uses four inputs in determining the AVDLR cost per hour (by T/M/S) as presented in the OP-20. The four variables include a Certified Actual Expenditure Cost per Hour, a CNA Demand Factor, Forecasted Programmatic Adjustments as submitted through the Cost Adjustment and Visibility Tracking System (CAVTS), and a baseline Escalation Factor/Rate Adjustment. The Certified Actual Expenditure variable is a base for determining funding requirements from the most recent certified Flight Hour Cost Report (FHCR). The certified figure in use is typically two years old since the prior year's execution numbers do not get certified by NAVAIR, Code 6.8, in time for incorporation into the following OP-20 calculation. Consequently, the FY06 AVDLR funding calculation uses FY04 cost per hour data as its base. The CNA demand factor is a multiplier that takes into account the age of the Navy's fleet of aircraft and the ensuing increase in failure rates of its major components. The Forecast Programmatic Adjustment allows for adjustments to funding levels based on inputs from NAVAIR's CAVTS web tool. The Escalation Factor/Rate Adjustment is a cumulative

DoD and NWCF combined rate used to adjust the cost per hour baseline (Keating & Paulk, 1998). These variables are used to generate the following equation to project AVDLR costs per hour: *Certified Actual Expenditures X Demand Factor (CNA) +/- Forecast Programmatic Adjustments/(CAVTS X Escalation Factor/Rate Adjustment ÷ Projected flight hours=Projected AVDLR cost per hour.*

The Consumables pricing model uses three inputs in calculating the SIC cost per hour. The three variables include the Certified Actual Expenditure Cost per Hour, Forecasted Programmatic Adjustments as submitted through CAVTS, and the NWCF baseline Escalation Factor/Rate Adjustment. These variables are used to generate the following equation to project consumables costs per hour: *Certified Actual Expenditures X Demand Factor (CNA) +/- Forecast Programmatic Adjustments/CAVTS X Escalation Factor/Rate Adjustment ÷ Projected flight hours = Projected consumables cost per hour.*

The Contract Maintenance pricing model uses two inputs in calculating the SIC projected contract cost per hour. The two variables include NAVAIR sponsored and Fleet-sponsored maintenance contracts. These variables are used to generate the following equation to project Contract costs per hour: *NAVAIR-sponsored maintenance contracts + Fleet-sponsored maintenance contracts ÷ Projected flight hours = Projected contract cost per hour.*

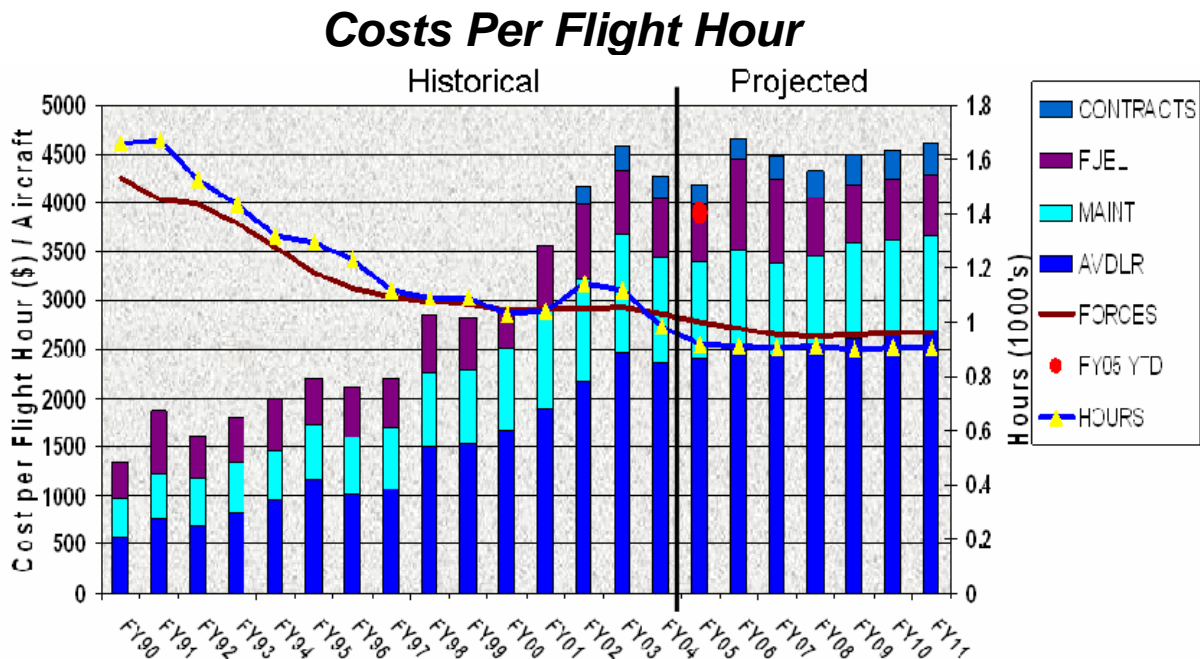


Figure 2. Histogram of Costs Per Hour.
Source: OPNAV 43 Flight Hour Program Brief May 2005.

Figure 2 is a historical representation depicting that as the costs per hour have increased, the number of flight hours and aircraft have decreased. The costs per hour in the outlying years that show decreases are associated with future engine innovations and the inclusion of platforms such as the V-22 shifting to Depot accounts. Of the overall \$122 million price increase to DoD Depot Maintenance, \$91 million will be FY06 distributed to Navy aircraft maintenance with the balance spread across various components and maintenance categories. The Navy Depot Maintenance Program decreased by \$124.7 million in FY06 in comparison to the previous fiscal year.

In briefs prepared by Peter Francis and Geoff Shaw on the *Effect of Aircraft Age on Maintenance Costs, 2000*; and Laurence Stoll and Stan Davis on *Aircraft Age Impact on Individual Operating and Support Cost Elements, 1993*, were early studies conducted by NAVAIR, the Center for Naval Analyses (CNA) and the CBO, concluded that this approach is better at sorting out factors that affect O&M costs in relation to aircraft maintenance (CBO, 2001). For example, CBO used data from the Navy's Visibility and

Management of Operating and Support Costs database for the years 1986 to 1999 for 13 different Navy aircraft totaling 164 observations. With the type of aircraft, year, inventory, and operation tempo held constant, one additional year of age was associated with an increase in Operations and Support costs of 2.4 percent per year and an increase in O&M costs of 2.6 percent per year. Unfortunately, programs are slowly having their budgets reduced or stopped all together because of the projection of inadequate funding in the outlying fiscal years. In spite of these facts, Naval Aviation still must maintain a level of force readiness capable of projecting combat power across the globe. Innovative thinkers such as that articulated by Vice Admiral Malone comprehends that combat capabilities are gained through strategic investments, "...involv [ing] more than applying increased dollars, but critical investments in readiness" (Malone, 2004).

D. INCREASING COST AWARENESS

Prior to August 2001, the institutional approach to readiness within Naval Aviation was readiness at any cost, i.e., pour dollars into achieving capabilities today at the expense of future capabilities. Now the emphasis is on achieving readiness through more efficient and innovative use of infrastructure, process management, personnel, and most of all, effort devoted to more careful use of every dollar. This new way of thinking is called cost-wise readiness.

To illustrate the difference between readiness at any cost and cost-wise readiness, one can compare the maintenance of the AN/APG-65/73 radar before and after the application of the cost-wise readiness approach. The AN/APG-65/73 radar is a critical component of the F-18 Super Hornet, providing fire control capabilities during air-to-air and air-to-ground missions. In the past if the radar failed, the Fleet could possibly declare it Beyond Capability of Maintenance (BCM) and send the entire radar to the depot, thus incurring the cost to buy a new radar. For every repairable asset there is a unit price and a net price. If an item is replaced, the unit price is the replacement cost that the Navy Inventory Control Point (NAVICP) pays to replace the asset from the original equipment manufacturer (OEM). The net price is the repair price that the organization pays using FHP money. An OEM is a company that builds components

which are used in products sold by another company. For example, a company separate from the one that actually markets and sells the computer may manufacture a hard drive in a computer. When the term OEM is used in relation to aircraft maintenance, it refers to the manufacturer that makes the component of the weapon system. Within the F-18 Super Hornet, Boeing, Michelin, General Electric, Raytheon, Honeywell, and Michelin are all OEMs that manufacture distinct components of the aircraft. At the AIMD NAS Lemoore, there is a Radar COE where AN/APG-65/73 radars are sent. Currently, the COE still processes BCM assets to the D-Level with goals of avoiding more BCM assets through its gained cross-functional focus, permanent Raytheon technician on station, and better business practices; all improvements that translate to cost avoidance as the Radar COE matures as a Fleet Readiness Center (FRC).

The COE will be discussed in greater detail in Chapter IV but was introduced to demonstrate the fundamental process changes that are taking hold in Navy aircraft maintenance.

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III. COST-WISE READINESS AND ENTERPRISE AIRSPEED INITIATIVES

A. GOALS AND VISION

On 10 September 2001, the Secretary of Defense outlined a vision for transforming the DoD in which he called for dramatic changes in management, technology, and business practices. The Secretary stated that transformation was a matter of utmost urgency because ultimately the security of the nation was at stake. The very next day, devastating terrorist attacks drew us into a global war against an unconventional enemy and underscored the need for defense transformation (DoD, 2005). Since 11 September 2001 (9/11), the reasons for change have become crystal clear to senior military leaders: transform, recapitalize, and modernize the Navy in order to preserve freedom and deter aggression from the enemy.

1. Navy Transformation

The Navy is transforming to meet new demands created by shifts in global threats to our nation and its allies. In so doing, it recognizes the need to modernize its weapon systems and reengineer its resources and requirements. The CNO recognized the necessity of establishing Naval doctrine to emphasize the synergy between the various commands as the Navy reacts to threat conditions and sets the primus for Naval preparedness and planning (OSD, 2004).

a. Sea Power 21

The Navy's guiding doctrine for transformation is outlined in *Sea Power 21*, a blueprint for change that will ensure the nation possesses a 21st Century Navy to meet 21st Century threats. Its goal is to align, organize, integrate, and transform the Navy to meet future challenges and capabilities. *Sea Power 21* encompasses the concepts Sea Strike, Sea Shield, and Sea Basing through a supporting triad of organizational processes: Sea Trial, Sea Warrior, and Sea Enterprise—initiatives that will align and accelerate the development of enhanced warfighting capabilities for the Fleet (Mullen, 2006.)

Sea Enterprise is essential to *Sea Power 21*. It is the Navy's endeavor to implement required business process change and create efficiencies, freeing resources for investment in recapitalization and transformation. This Navy Enterprise alignment is a fundamental change to the business of manning, training, and equipping the Navy. The Navy is moving away from decentralized management organizations and processes toward adopting an organizational behavior model with a single focus: providing operational forces ready for tasking in the most cost-effective manner. The enterprise management concept establishes a strategic linkage between warfare enterprises (i.e., Surface Warfare, Naval Aviation, Undersea Warfare, etc.) and support elements (i.e. Manpower, Training & Education, Acquisition, Technical Authority, Logistics, Installations, Science & Technology, etc.). These enablers support the Fleet Readiness Enterprise in managing value streams, promoting cost transparency, and leveraging common processes and metrics to assess effectiveness and efficiency in delivering warfighting surge capabilities to the combatant commanders (DoD, 2006.)

b. Fleet Readiness Plan

The Fleet Response Plan (FRP) is the operational readiness framework through which the Navy meets global Combatant Commander (COCOM) requirements for forward deployed forces and crisis surge response. It supports *Sea Power 21*. The FRP enables the Navy to respond to emergent COCOM requests for forces in the case of a national crisis or a contingency operation. FRP is mission-driven, capabilities-based, and provides the right readiness at the right time, and at the right cost (HASC, 2006). It changes the way we operate, train, man, and maintain the Fleet. CNAF has the responsibility of manning, equipping, and training Naval aviation forces. Previously these functions were based on an 18-month readiness cycle. The advent of FRP and its flexibility puts CNAF in the position of making long-range planning decisions based on greater uncertainty. The essence of FRP is "targeted readiness" finding new and cost-effective ways to tailor the mission readiness of Naval forces (Badertscher, Bahjat, & Pierce, 2005). With FRP, the Navy can deploy agile, flexible, and scalable Naval forces capable of surging quickly to deal with unexpected threats, homeland defense, humanitarian disasters, and contingency operations (HASC, 2006).

A key element in the success of the FRP has been the implementation and maturation of the Regional Maintenance Plan, a 1990's initiative to gain efficiencies by consolidating like functions in a geographic region, called Regional Maintenance Centers (RMC). The RMCs have the responsibility as well as the resources and flexibility to sustain readiness and adapt to changing priorities in maintaining a surge ready force. Like the RMC concept, the aviation community has developed a similar initiative, FRCs, a component developed from the 2005 BRAC process (HASC, 2006). The concept of the FRC will be discussed in greater detail in section III.B.3 of this chapter.

2. Naval Aviation Transformation

Naval Aviation has always been successful at generating readiness; however, it has always been accomplished at a great cost. Traditionally, aviators receive funding based on the number of flight hours completed. By all accounts, the number of flight hours accomplished is a valid measurement to ensure pilots remain operationally proficient to confront unconventional threats. Further assessment by aviation experts identified the occurrence of flight operations over and beyond the basic flight hour requirements. Flying for the sake of increasing funding levels is a reversal of common business thinking, a waste of money. Excessive flight hours increased the occurrence of aircraft needing unscheduled or corrective maintenance, decreased the mean time between maintenance (MTBM), and increased labor and material costs. This assessment required a change in how readiness is characterized; rather than require "readiness at any cost", senior leadership recognized that a shift in paradigm was necessary to meet the FRP for future surge requirements. Maintaining Naval Aviation today while building the aviation forces of tomorrow requires the aviation community to embark on a "cost-wise readiness" journey to ensure that an excessive amount of current readiness is not purchased today at the expense of future readiness requirements. Inefficiencies resulting from stockpiling spares, inept maintenance operations, or constrained processes negatively impact the ability to purchase future aircraft capabilities.

a. Naval Aviation Enterprise

The Naval Aviation Enterprise (NAE) system is a direct subset of the Sea Enterprise initiative. It is a warfighting partnership forged between aviation stakeholders where independent issues affecting multiple commands are resolved on an Enterprise-wide basis. The enterprise approach creates synergy between people, readiness, and costs (Malone, 2004) in order to achieve NAE's vision "to deliver the right force, with the right readiness, at the right cost, at the right time-today, and in the future" (Badertscher, et al., 2005).

The efficiency and effectiveness of NAE is measured through a single Fleet driven metric of *aircraft ready for tasking (RFT) at reduced cost*. This metric tracks how well the NAE delivers on the things it values: cost-wise readiness (tied to the demands of COCOMs); improved time on wing (better equipment with better maintenance so that it stays on the aircraft longer); greater speed/reduced cycle time (aircraft and components spending less time in maintenance); improved reliability (quality); reduced total cost; and implementing process efficiencies (Ireland, 2006).

The concept for the current NAE program originated in the late 1990s when problems in the aviator production and training pipeline led to pilot and Naval Flight Officer shortfalls. In 1998 the Naval Aviation Pilot Production Improvement (NAPPI) program was developed to guide the aviation community in understanding and managing the interdependencies of manpower, training, and equipment – three entities that had historically operated independently. What was once a disjointed, stovepiped process became coordinated and aligned, and the process became faster and more effective. Several hundred additional pilots were produced without spending any additional money. The program delivered exactly what the Naval aviation community needed, a more effective force. With NAPPI, Naval Aviation had the beginnings of an enterprise (NAF, 2005).

The NAE enables communication across all elements of the Enterprise, fosters organizational alignment, encourages inter-agency and inter-service integration, stimulates a culture of productivity, and facilitates change to advance and improve readiness. Working together optimizes the use of existing resources, manages the cost

associated with generating readiness, and harnesses change as a positive force within [the] Navy and Marine Corps (Badertscher, et al., 2005).

(1) **NAE Organizational Structure.** The organizational structure of the NAE consists of a group of core stakeholders, senior leaders within the aviation community; and a Board of Directors comprised of representatives from approximately 20 organizations that are involved in all aspects of Naval Aviation readiness (Badertscher, et al., 2005). Additionally, the NAE has three Cross Functional Teams (CFT): Readiness, Training, and Cost Management; and a transition team working on human capital strategy (Navy Office of Information, 2005). The NAE core stakeholders include the following members:

- Commander, Naval Air Forces (NAE Chief Executive Officer)
- Commander, Naval Air Systems Command (NAE Chief Operating Officer)
- Deputy Commandant for Aviation, Headquarters Marine Corps
- Commander, Naval Air Force, U.S. Atlantic Fleet
- Chief of Naval Air Training
- Director, Air Warfare Division (OPNAV N78)
- Director, Fleet Readiness Division (OPNAV N43)

(2) **NAE Strategic Goals.** The NAE strategic goals are to balance current and future readiness, reduce the cost of doing business, enhance agility, and improve alignment to attain and maintain visibility across the Enterprise (Badertscher, et al., 2005). The intricate elements of these goals include:

- Balance Current and Future Readiness
 - Support the FRP safely, with improved organizational alignment and operational effectiveness

- Maintain direct, frequent, and continuous communication with Navy Type Wing and Marine Wing Commanders to produce combat-ready aircraft at reduced cost
- Strengthen development and acquisition to maximize the return the recapitalized funds
- Reduce the Cost of Doing Business
 - Work across Systems Commands (SYSCOM)/Joint boundaries to maximize our share of the resources
 - Provide more products and more capability per dollar to the Fleet
 - Use dollars saved through improved efficiencies to upgrade and modernize our aging force
- Enhance Agility
 - Improve our responsiveness and adaptability
 - Communicate better with the Fleet, streamline decision making, compress management layers, demand accountability, and tailor product-delivery processes
- Improve Alignment
 - Align with the strategic direction of higher authority outside the Enterprise
 - Align NAE functions and processes to provide aircraft ready for tasking at reduced cost
 - Communicate our vision so that all NAE employees have a sense of purpose and clearly understand the meaning of their individual contributions to the NAE

(3) **Achieving Cost-Wise Readiness.** “Cost-wise readiness” is a term repeated in nearly every article reviewed for this research, but what exactly does cost-wise readiness mean, and what are the paths for achieving cost-wise readiness?

Cost-wise readiness can be interpreted as expending maintenance monies in the most efficient manner to obtain the highest quality of maintenance services in order to ready aircraft for any potential mission. Essentially, commands must ensure wise decisions are made before each dollar is spent, and each expense serves an intended purpose and can be fully validated as being necessary toward keeping aircraft ready for surge capabilities. Commands must also employ cost-wise techniques in incorporating continuous process improvement (CPI) initiatives in maintenance operations and workforce development.

There are a variety of ways the NAE can achieve cost-wise readiness. The following are paths to achieving cost-wise readiness (CNAF, 2006):

- Properly manage aircraft RFT requirements (mission and operational)
- Manage inventory and investments
- Reduce operating expenses
- Identify and address interdependencies
- Manage and reduce variability
- Identify and manage constraints
- Create a culture of CPI
- Revolutionize the business of Naval aviation maintenance
- Increase velocity of the local off-flight line repair cycle
- Increase the density of off-flight line repair loop
- Reduce cycle time to repair
- Interdict BCM repairs

b. Naval Aviation Readiness Integrated Improvement Program (NAVRIIP)

At about the same time NAPPI stood up; there were also significant challenges with Naval aviation material readiness. In 1998, the Commander-in-Chief,

U.S. Pacific Fleet, commissioned a study called *Aviation Maintenance Supply Readiness* (AMSR). The AMSR study began identifying the root causes of gaps between readiness requirements and resources. It clearly demonstrated that process improvement, based on quantifiable metrics and data collection, was critical to understanding the reasons behind the significant supply shortfalls that were hampering Naval aviation readiness. While AMSR ventilated the root causes, it lacked a construct for implementation, so in 2001, the Naval Aviation Readiness Integrated Improvement Program (NAVRIP) was created (NAF, 2005).

NAVRIP is an enabler of the NAE. Its goal is to determine what inventory levels are required to maintain a certain ready to train or operational status and matches the right amount of readiness and cost to achieve and sustain those levels. NAVRIP helps understand and to control cost drivers. It is focused on achieving aircraft RFT at a reduced cost which is accomplished by creating a culture of cost-wise readiness and CPI (Badertscher, et al., 2005).

B. COST-WISE INITIATIVES

1. *AIRSpeed*

AIRSpeed is NAVRIP's architecture for operationalizing cost-wise readiness across the NAE. It is characterized by an integrated culture of self-sustaining, CPI aligned toward delivering mission requirements at reduced resource cost thus enabling world-class logistics excellence for the NAE in support of the T/M/S teams. *AIRSpeed* provides the planning, training, integration, sustainment, and monitoring of business practices across the NAE (CNAF, 2006).

There are three *AIRSpeed* programs that fall under the umbrella of the NAE: Depot, Enterprise, and NAVAIR. Each is designed to employ industry-proven best business processes and methodologies to reduce cycle time, improve productivity, and establish a culture of continuous improvement. Depot *AIRSpeed* focuses on improving efficiencies throughout depot production by reducing the cycle time of refurbishing aircraft by improving the material management of production processes thus increasing productivity at a lower cost. Enterprise *AIRSpeed* allows managers to look at the system

holistically and enables them to make local decisions. This initiative focuses on the total aviation solution within all levels of supply and maintenance (Badertscher, et al., 2005). It is designed to integrate the decision making processes of asset positioning and visibility with those of planning and scheduling across the entire logistics and operations chain. Enterprise *AIRSpeed* is designed to become a self-sustaining program through the utilization of the “train the trainer” approach (CNAF, 2005a). The third initiative, NAVAIR *AIRSpeed*, is a cultural transformation that extends the success realized by Depot and Enterprise *AIRSpeed* to transactional and non-production service environments and at every level. It is the solution to a fundamental need to change the way business is conducted at every level: Headquarters, Competency, Program Executive Office, Program Manager Air (PMA), Integrated Product Team (IPT), and Business Unit (Badertscher, et al., 2005).

The differences between Depot and Enterprise *AIRSpeed* are that Enterprise *AIRSpeed* focuses on the total aviation solution at all levels of supply and maintenance, whereas Depot *AIRSpeed* concentrates on the micro level at the aviation depots. Each of these programs integrate best business practices tools of Lean, Theory of Constraints (TOC) (basic and advanced), and Six-sigma to transform the repair and replenishment process from a “push” to a “pull” system and identifies and manages constraints, variability and interdependencies within the system (CNAF, 2006).

What sets *AIRSpeed* apart from all other efficiency models, is that it is a composite approach that operates under a triad of existing methodologies: TOC, the Lean manufacturing process and Six-sigma. TOC is the overarching architecture applied for *AIRSpeed*. It allows an organization the ability to identify and focus on the limiting variables, or constraints, that have the greatest overall impact on productivity. TOC answers three questions: What to change, what to change into, and how to effect that change. The Lean manufacturing process focuses on identifying and removing waste and/or steps that don’t add value to the final product. Six-sigma reduces variation across repetitive processes.

a. Lean

The terms “lean, lean manufacturing or lean production” can be defined as “a systematic approach to identifying and eliminating non-value-added activities (waste) through continuous improvement by flowing the product at the pull of the customer in pursuit of perfection” (MAMTC, 2006). By eliminating waste (muda), quality is improved, production time is reduced, and cost is reduced. Lean "tools" include CPI (kaizen), "pull" production process (by means of kanban) and mistake-proofing (poka-yoke) (Apte & Kang, 2006).

Although the origins of Lean can be traced to the Scientific Management principles of Frederic Taylor, and the automobile manufacturing of Henry Ford, the modern day principles of Lean Production are embodied in “Just in Time (JIT) System” and the “Toyota Production System” (Apte & Kang, 2006). Japanese leaders at the Toyota Motor Company developed these theories during the Japanese re-building effort following the Second World War. Because Japan was faced with declining human, material, and financial resources in their factories, Toyota leaders were forced to find new ways to become efficient, lower costs, improve manufacturing practices, and minimize the consumption of resources that did not add value to the manufacturing process (MAMTC, 2006). The “Toyota Production System” focused on the reduction of eight types of wastes in manufacturing or service processes:

- Overproduction-Making more than what is needed at a specific time
- Transportation- Moving products farther than is minimally required
- Waiting-Products waiting on the next production step, or people waiting for work
- Inventory-Having more inventory than is minimally required
- Motion- People moving or walking more than minimally required
- Non Value Added Processing
- Defects-The effort involved in inspecting for and fixing defects
- Underutilization of people

The term “lean production” was later coined by Womack, Jones & Roos in their 1990 best seller, *The Machine that Changed the World: The Story of Lean Production*. The book chronicles the transitions of automobile manufacturing from craft production to mass production to lean production. This publication outlined the five requirements of a lean enterprise:

- Specify value in the eyes of the customer
- Identify the value stream and eliminate waste
- Make value flow at the pull of the customer
- Involve and empower employees
- Continuously improve in the pursuit of perfection

At the heart of Lean is the determination of value. Value is defined as form, feature, or function for which a customer is willing to pay. All other aspects of the process that do not add value are deemed waste. The Lean framework is used as a tool to focus resources and energies on producing the value-added features while identifying and eliminating non-value added activities. Processes in Lean are thought of as value streams. Lead-time reduction and the flow of the value streams are the major areas of focus in Lean. *Value-stream mapping* helps teams understand the flow of material and information in creating and delivering the product or services being offered to the customer by the organization (Apte & Kang, 2006).

Lean management is about operating the most efficient and effective organization possible, with the least cost and zero waste. To fully understand this concept, managers must understand that a lean organization will produce fundamental changes to those found in a traditional organization. Table 1 is an example of how various functions are interpreted as a result of implementing Lean production concepts.

Concept	Traditional Organization	Lean Organization
Inventory	An asset, as defined by accounting terminology	A waste-ties up capital and increases processing lead-time
Ideal Economic Order Quantity & Batch Size	Very large-run large batch sizes to make up for process downtime	ONE-continuous efforts are made to reduce downtime to zero
People Utilization	All people must be busy at all times	Because work is performed based directly upon customer demand, people might not be busy
Process Utilization	Use high-speed processes and run them all the time	Processes need to only be designed to keep up with demand
Work Scheduling	Build products to forecast	Build products to demand
Labor Costs	Variable	Fixed
Work Groups	Traditional (functional) departments	Cross-functional teams
Accounting	By traditional Financial Accounting Standards Board guidelines	"Through-put" Accounting
Quality	Inspect/sort work at end of process to make sure errors are found	Processes, products, and services are designed to eliminate errors

Table 1. Traditional Organization and Lean Organization.

Source: Jerry Kilpatrick, 2003. Lean Principles. Utah Manufacturing Extension Partnership.

In summary, the Lean methodology:

- Focuses on maximizing process velocity
- Provides tools for analyzing process flow and delay times at each activity in a process
- Emphasizes *Value-stream Mapping* which centers on the separation of "value-added" from "non-value-added" work with tools to eliminate the root causes of non-valued activities and their cost
- Recognizes and attempts to eliminate eight types of waste/non-value-added processes
- Creates workplace organization through the Six *S* methodology (different from Six-sigma) consisting of safety, sort, straighten, sustain, shine, and standardize
- Produces a better workplace through the Toyota principle of "respect for humanity" (Apte & Kang, 2006).

Lean concepts are essential in organizing the supply and repair chains. Recent Lean concepts implemented on aircraft carriers have proven to be effective in increasing the efficiency of maintenance operations and lowering the labor cost for each maintenance repair. Changes created by simply reorganizing maintenance parts has cut down the amount of time maintainers use to locate engines from two hours to 45 minutes. Another improvement was discovered by mapping the movement of repair crews and their equipment during repairs. This resulted in the decrease of the movement of aircraft parts and people by 97 percent and 62 percent, and reduced forklift travel by 75 percent. By identifying potential areas for improvement, eliminating unnecessary “muda” in operations, and centrally locating critical repair components and equipment in the vicinity of its use reduces non-value added steps, boosts productivity, and lessens turn-around time (TAT).

Before *AIRSpeed* gained in popularity, these types of Lean initiatives just didn’t happen quickly, in fact many cost reduction and improvement initiatives met “institutional resistance”. Transformation goals outlined in the Quadrennial Defense Review, and CNO policy have forced the hands of bureaucracy to concede to the achievement of a cost-wise defense force. As such, ideas for reducing costs are readily introduced from the deck plate, explored for feasibility, and quickly implemented at minimal costs. Monies earned from productivity increases and reduced TAT can be spent on the purchase of needed aircraft and spare parts. Lean production concepts can help to achieve these types of outcomes.

b. Theory of Constraints (TOC)

The Theory of Constraints (TOC) is a management philosophy and business unit strategy created by Dr. Eliyahu M. Goldratt. It is a particular body of knowledge that addresses effective management of various organizations as systems by focusing on the constraint or bottleneck in the process. TOC views organizations as systems consisting of resources which are linked by the processes they perform (interdependencies). Inherent in such systems are variability in its processes, suppliers and customers. Within that system, a constraint is defined as any element that restricts the flow of the system, consistent with demand; otherwise, its throughput would go to

infinity. A market, vendor, or an internal resource can be a constraint. The interdependencies and variability between and within system processes are similar in nature to the structure of a chain. Just as the strength of a chain is governed by the weakest link, TOC maintains that the ability of the organization to achieve its goal is governed by a single or very few constraints (Hickey et. al, 2003).

(1) **Tenets of TOC.** TOC requires a fundamental shift in how an organization is viewed, understood, and measured. TOC eliminates process constraints so the workforce can focus on efficient operations. It is based on the premise that the rate of revenue generation is limited by at least one constraining process (i.e. a bottleneck). Only by increasing throughput (production rate) at the bottleneck process, can overall throughput be increased. To adequately implement TOC requires a five step focused approach in order to pursue ongoing improvement. These steps include:

- ❖ Identify the system's constraint
- ❖ Decide how to exploit the system's constraint
 - Maximize the constraint so throughput is maximized now and in the future
 - Figure out what are the market values relative to the industry's current offerings, and align the organization to deliver value as solutions to the market's high value problems
- ❖ Subordinate everything else to the above decision
 - Once the constraint has been identified, do not allow the improvement initiatives to interfere with the high priority of the above decisions. Policies, processes or resources must be altered or managed in order to support the decision to address the constraint
- ❖ Elevate the systems constraint
 - Generate more sales if market is a constraint
 - Acquire new sources for material (vendor constraint)

- Purchase more equipment, hire more employees, reduce setup costs, add additional shifts, etc. (internal resource constraint)
- ❖ Decide if the constraint has been broken or has shifted (if constraint is not broken or shows sign of shifting, return to step 4; if the constraint is broken, return to step 1)
- Don't allow inertia to become the systems constraints. When one constraint is broken, go back to Step 1

However, prior to the identification of the constraint, it is important to understand the basic facts about the system. Primarily, it is important to know the system and its purpose as well as the measurement of the system's goal. TOC requires the organization to have clear and concise verbalization of its goals because constraints are best identified and dealt with in relation to the system's objective as constraints have the ability to prevent organizations (manufacturing particularly) from achieving its goals (Hickey et. al, 2003). Additionally, TOC measures if an organization is meeting its goal (in most cases, the goal of making money). TOC starts by categorizing what a firm does with its money in three ways:

- Throughput: The rate at which the organization generates money through sales
- Inventory/Investment: All of the money that the organization spends on things it intends to turn into throughput
- Operating Expense: All of the money the organization spends in order to turn inventory into throughput

The challenge and power of allocating all of the money in the system into one of three mutually exclusive and collectively exhaustive categories lies in the improved ability of the organization to evaluate the impact of decisions relative to the goal of making money (Hickey et. al, 2003).

(2) **Operational Elements of TOC.** TOC employs a drum-buffer-rope (DBR) method in its manufacturing process as a means of improving

throughput and increasing net profit. The drum is the detailed master production schedule that emerges when demand is matched with the capabilities of the system's constraints. The buffer is the protection allotted to the constraints. This ensures if disruptions occur in the manufacturing process, work will still be available to the constraint. Rope synchronizes all resources to the beat of the drum by releasing just the right materials into the system in the right quantity, and at the right time (Hickey et al., 2003). As such, TOC is essentially a "pull system" that sends material upstream based on demand, in this case, the beat of the drum is the gatekeeper for demand. Simply stated, TOC is a key element of the JIT delivery system.

c. Six-Sigma

Six-sigma is based on the assumption that the outcome of the entire process will be improved by reducing the variation of multiple elements, inputs and sub-processes (CNAF, 2005a). The methodology is focused on reducing variation and improving process yield by following a problem-solving approach using statistical tools to eliminate variation between the goods or services delivered and what the customer expects (therefore reduces time spent on rework). The goal of Six-sigma is to work toward a systematic management of the variation until defects are eliminated from the product, and to deliver reliability, performance, and value to the customer on a world-class level.

(1) **Six-Sigma Methodology.** There are two key methodologies that are involved with Six-sigma. These are DMAIC and DMADV. DMAIC is used in the improvement of an existing process in an existing business, and DMADV is used to create either new process designs or product designs in ways that result in mature, predictable, and defect-free performance for the company (Gupta, 2003).

The basic DMAIC methodology consists of five specific phases. These phases include: define, measure, analyze, improve, and control (Gupta, 2003). It is important to define what the goals are when it comes to process improvement and how these are consistent with both enterprise strategy and customer demands. Measure involves a baseline of the current processes so that future comparisons can be made. The third phase includes analyzing the relationship between the factors based on causality.

The fourth phase includes improving and optimizing the process based on the analysis that was created. The last phase includes controlling the process capability, the production transition, and future processes (Gupta, 2003). It is also important to ensure that the changes that have been made are continuously monitored so that future variances can be seen and quickly corrected before they are allowed to result in defects (Gupta, 2003).

The DMADV methodology also has five phases, but some are slightly different from those seen in the other methodologies. These five phases include: Define, measure, analyze, design, and verify (Gupta, 2003). The define step in DMADV is the same as in DMAIC. It is important to define the activity design and goals as they relate to the enterprise strategy and customer demand (Gupta, 2003). After which, it is important to measure the production process capabilities, the product capabilities, the risk assessment, and other issues (Gupta, 2003). Once this has been completed, one must analyze the alternatives for design and create or evaluate different design elements until one is chosen. From there, the selected design will be developed in detail, optimized, verified, and require simulation tests to be conducted. The last step is to verify the design that was chosen, address some pilot runs, implement the process that was agreed upon, and then hand the process over to the owners of the company (Gupta, 2003).

(2) **Key Roles of Six-Sigma Implementation.** The Six-sigma approach, however, cannot just be implemented without a great deal of dedication toward the process. There are five key roles that must be addressed for a Six-sigma approach to be successful in its implementation. These roles include: executive leadership, champions, master black belts, black belts, and green belts (Gupta, 2003).

The first key role, executive leadership, includes not only the Chief Executive Officer but other top management as well. These individuals are responsible for the actual development of the vision that they will use for the Six-sigma implementation. These individuals also empower others that have specific roles so that they have the resources and the freedom to explore new ideas and make improvements. The second key role is that of the champions who are charged with the duty of integrating Six-sigma into the organization (Gupta, 2003). The next level, master black belts, are

identified and selected by the champions, and they are in-house experts to coach others on Six-sigma (Gupta, 2003). All of their time is spent on this, and they help assist the champions and guide the black belts and the green belts. In addition to working with statistics, they also spend time ensuring that the Six-sigma approach is integrated across all departments and functions. The black belts operate under these individuals to make sure that the Six-sigma approach is applied to specific projects (Gupta, 2003). They also devote all of their time to Six-sigma and generally focus most of their attention on the project execution. At the last level, green belts, is standard employees that work on Six-sigma in addition to the rest of their duties (Gupta, 2003). They work under the guidance of the black belts and they help to support them so that overall results can be achieved. There are specific training programs that are utilized to ensure that roles can be properly performed (Gupta, 2003). Overall, much of what is used in Six-sigma is not all that new, but the old tools are used together, and a far greater effort is put into them than what has been seen in the past.

d. AIRSpeed Successes

The *AIRSpeed* program is the Navy's implementation of Lean Six-sigma. As stated by the Secretary of the Navy Donald Winter, in a memorandum in May 2006, "Lean Six-sigma (LSS) is a proven business process that several elements of the Navy and Marine Corps have initiated including training over 500 black belts and 1500 green belts who have facilitated 2800 events and projects. These activities have averaged a 4:1 return on investment (ROI)." The following examples demonstrate some success stories in the implementation of *AIRSpeed*.

- In October 2005, Naval Air Warfare Center accounting practices yielded an annual savings of \$176.9K with an additional anticipated saving of \$146.3K in waste elimination.
- Since April 2004, AIMD Whidbey Island reduced J-52 aircraft engine repair time from 468 hours to 233 hours and reported significant inventory and operating cost savings.

- Since February 2006, AIMD Patuxent River has seen increased savings due to a 10% inventory reduction and a reallocation of 166 hours of full-time employees.
- In June 2005, NADEP (Naval Aviation Depot) Cherry Point revamped the Beneficial Suggestion Program. The “5 year” process is now encompassed in a 30-day turnaround, with all beneficial suggestions being implemented within a 30-180-day window.
- In June 2006, NAVAIR’s PMA offices began replicating successes of other PMA offices, including one office that saw an estimated \$163K/year savings due to reducing processing time from 240 days average to a predicted average of 15 days. Other organizations that have begun *AIRSpeed* implementation involve weapons, training systems, support equipment, safety, test ranges, reports, fleet support, and human resources (Apte & Kang, 2006).
- Cherry Point reduced CH-46 TAT from 215 days to 170.
- Jacksonville reduced EA-6B re-wing TAT from 594 days to 450.
- North Island reduced F/A-18 TAT from 192 days to 132, the average Work-In-Progress (WIP) reduction was 37%

In these instances, by focusing on four key metrics: inventory, cycle time, quality, and total cost; the Enterprise model NAVRIIP/*AirSpeed* has helped to improved all aspects of maintenance from Organization-level through Depot-Level and supply and acquisition responsiveness – for the benefit of the warfighter.

2. Base Realignment and Closure (BRAC)

Base Realignment and Closure (BRAC) is the process the DoD uses to reorganize its installation infrastructure to more efficiently and effectively support its forces, increase operational readiness and facilitate new ways of doing business. Public Law 101-510, “Defense Base Closure and Realignment Act of 1990,” as amended, established the procedures under which the Secretary of Defense may realign or close military

installations inside the United States and its territories. Congress authorized a BRAC 2005. The law authorized the establishment of an independent Commission to review the Secretary of Defense recommendations for realigning and closing military installations (DODIG, 2005).

A primary objective of BRAC 2005, in addition to realigning base structure, was to examine and implement opportunities for greater Joint activity. Prior BRAC analyses considered all functions on a Service-by-Service basis, and therefore, did not result in the Joint examination of functions that cross Services (DODIG, 2005). The Joint Cross-Service Groups (JCSG) addressed issues that affect common business-oriented support functions, examined functions in the context of facilities, and developed realignment and closure recommendations based on force structure plans of the Armed Forces and on the selection criteria of three major categories: Military Value, ROI, and Impact. Table 2 provides a detailed description of the selection criteria (GAO/NSIAD-95-133, 1995).

The JCSGs reported their results through the Infrastructure Executive Council and the Infrastructure Steering Group. The Office of the Secretary of Defense established seven JCSGs—Education and Training, Headquarters and Support Activities, Industrial, Intelligence, Medical, Supply and Storage, and Technical (DODIG, 2005).

The Industrial JCSG was one of six JCSGs established on 15 March 2003, by the Under Secretary of Defense for Acquisition, Technology, and Logistics (USD (AT&L)). Later, a seventh JCSG was added. Each JCSG is responsible for overseeing the Joint cross-service analysis of functions within their area (DODIG, 2005). Specific to this research, the analysis and recommendations of the Supply and Storage JCSG (S&S JCSG), and the Industrial JCSG will be discussed only.

During the BRAC 2005 proceedings, the S&S JCSG was chartered to conduct a comprehensive review of DoD's common business-oriented S&S logistics functions. Chaired by the Director, Defense Logistics Agency (DLA), the Committee proposed the consolidation of numerous supply, storage, and distribution functions and associated inventories of the Defense Distribution Depots (DD) with other supply, storage and distribution functions and inventories that existed at NADEPs; retaining only the

minimum necessary supply, storage, distribution functions and inventories required to support depot operations, maintenance, and production. The S&S JCSG further recommended that the NADEPs serve as a wholesale Forward Distribution Point, and all other wholesale storage and distribution functions and associated inventories be transferred to the San Joaquin Strategic Distribution Platform (BRAC, 2005b).

Category	Criteria
Military Value	<ol style="list-style-type: none"> 1. Current and future mission requirements and the impact on operational readiness of DoD's entire force. 2. The availability and condition of land, facilities, and associated airspace at both the existing and potential receiving locations. 3. The ability to accommodate contingency, mobilization, and future total force requirements at both the existing and potential receiving locations. 4. Cost and manpower implications.
Return on Investment	<ol style="list-style-type: none"> 5. The extent and timing of potential costs and savings, including the number of years, beginning with the date of completion of the closure or realignment, for the savings to exceed the costs.
Impact	<ol style="list-style-type: none"> 6. The economic impact on communities. 7. The ability of both the existing and potential receiving communities' infrastructures to support forces, missions, and personnel. 8. The environmental impact.

Table 2. DoD Criteria for Selecting Bases for Closure or Realignment.
Source: GAO Report *Military Bases, Analysis of DOD's 1995 Process and Recommendations For Closure and Realignment*.

The recommendation proposes to achieve economies and efficiencies that enhance the effectiveness of logistics support to operational Joint and expeditionary forces. It reconfigures the Department's wholesale storage and distribution infrastructure to improve support to the future force, whether home-based or deployed. It transforms existing logistics processes by creating four continental U.S. support regions, with each

having one Strategic Distribution Platform and multiple Forward Distribution Points. Each Strategic Distribution Platform will be equipped with state-of-the-art consolidation, containerization, and palletization capabilities, and the entire structure will provide for in-transit cargo visibility and real-time accountability. Distribution Depots, no longer needed for regional supply, will be realigned as Forward Distribution Points and will provide dedicated receiving, storing, and issuing functions, solely in support of on-base industrial customers such as maintenance depots, shipyards, and air logistics centers. Forward Distribution Points will consolidate all supply and storage functions supporting industrial activities, to include those internal to depots and shipyards, and those at any intermediate levels that may exist. This consolidation eliminates unnecessary redundancies and duplication, and streamlines supply and storage processes (BRAC, 2005b).

During the same BRAC period, The USD (AT&L) was appointed to Chair the Industrial JCSG. The purpose of the Industrial JCSG is to identify opportunities for consolidation, closure, or downsizing of the DoD Industrial Base. The scope of the Industrial JCSG is composed of three functional areas: maintenance; munitions and armaments, formerly named ammunitions and armaments; and ship overhaul and repair, formerly named shipyards overhaul and repair (DODIG, 2005).

3. Fleet Readiness Centers (FRC)

During the BRAC 2005 proceedings, the Maintenance Subgroup, chaired by the Principal Deputy Assistant Secretary of the Air Force (Installations, Environment, and Logistics), conducted an analysis to determine the feasibility of consolidating NADEPs and AIMD functional levels into FRCs (DODIG, 2005). This evaluation considered the consolidation of aircraft maintenance services of 42 Navy and Marine Corps facilities and the distribution of their maintenance functions and workload to form six regionally-based FRCs.

Under the proposed FRC regional alignment plan, the maintenance functions of AIMDs Norfolk, Oceana, and NAS Corpus Christi; NADEPs Camp Pendleton Detachment Oceana, Jacksonville Detachment Norfolk, Jacksonville Detachment

Oceana, and Naval Air Warfare Center Aircraft Division Lakehurst (NAWCAD LKE) Detachment Norfolk will be consolidated under FRC Mid-Atlantic. AIMD Atlanta and Naval Air Reserve Station New Orleans will consolidate its maintenance functions at a FRC satellite in New Orleans, and the AIMD Patuxent River will serve as a second Satellite FRC under FRC Mid-Atlantic.

FRC East will consolidate the NADEP Cherry Point, AIMD Willow Grove, and Marine Aviation Logistics Squadron (MALS)-14 Cherry Point functions. Satellite FRCs will be positioned at New River, North Carolina for the NADEP Camp Pendleton Detachment New River, MALS-26, and MALS-29 units. Another satellite will be located at Beaufort, South Carolina for the NADEP Jacksonville Detachment Beaufort. A FRC “affiliated” site will be established in Quantico for the HMX-1 unit.

FRC Southeast will include NADEPs Jacksonville and Jacksonville Detachment Cecil Field, and AIMDs Brunswick and Jacksonville. Satellite FRCs will be established at Mayport, Florida (consolidating AIMD Mayport, NADEP Jacksonville Detachment Mayport, and NAWCAD LKE Detachment Mayport) with an additional satellite at Key West, Florida.

FRC Southwest will integrate the depot maintenance of NADEPs North Island, North Island Detachment North Island, and AIMD North Island. FRC Southwest will have four additional satellite facilities: (1) NADEP North Island Detachment Pendleton, and MALS-39 will be located at Camp Pendleton, (2) Maintenance at Point Mugu will be reorganized under the satellite facility, FRC Point Mugu (3) MALS-13 and NADEP North Island Detachment Yuma will be merged at FRC Southwest Site Yuma, Arizona, and (4) NADEP North Island Detachment Miramar, and MALS-11 and MALS-16 will be located at the Miramar FRC site.

The fifth location, FRC Northwest will optimize the functions of NADEP North Island Detachment Whidbey Island. No satellite facilities have been proposed at this time.

The final consolidation point will be FRC West located in Lemoore. At this facility the maintenance functions of AIMD Lemoore and NADEP North Island Detachment Lemoore will be integrated. Additionally, two satellite locations are

planned: one in Fallon, Nevada and another at Fort Worth, Texas. The Fallon site will merge the functions of NADEP North Island Detachment Fallon. The Fort Worth site will serve as a location for the F/A-18 support maintenance from AIMD Atlanta and the maintenance of and the Naval Air Reserve, Fort Worth. Figure 3 shows where the proposed FRCs will be located.

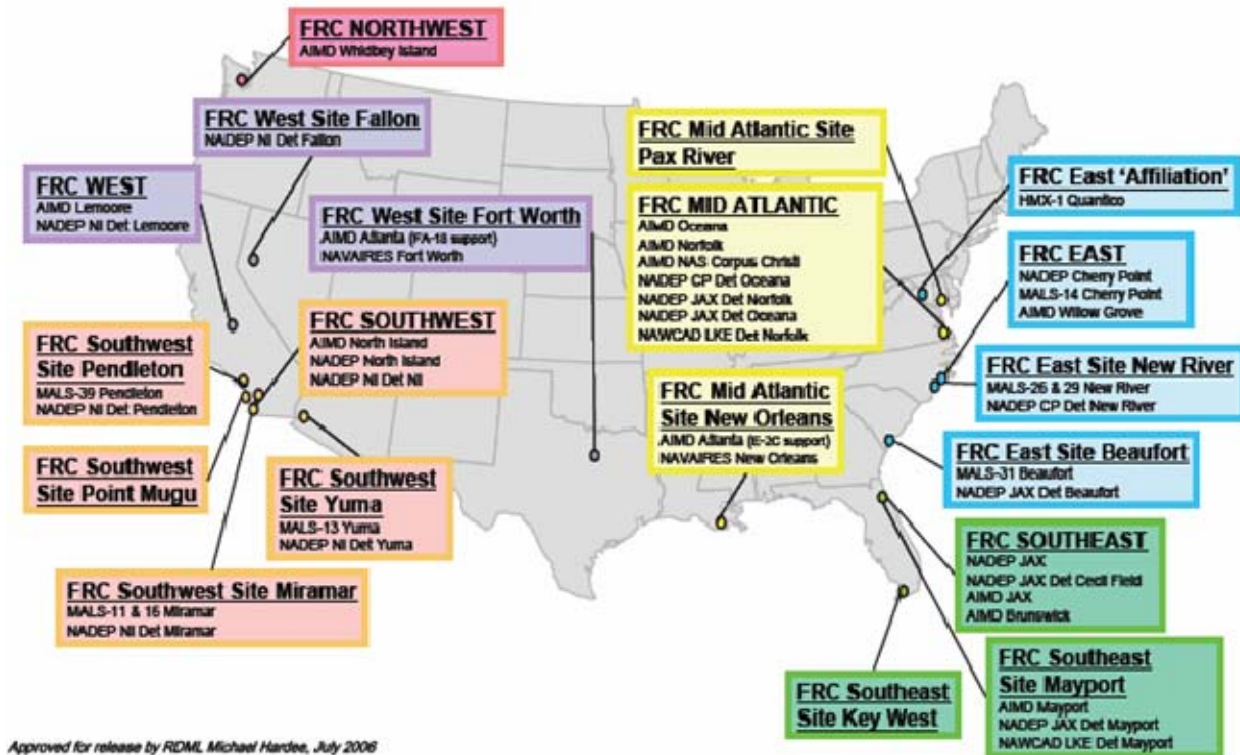


Figure 3. Fleet Readiness Center Regional Alignment Plan.
Source: Chief Naval Air Forces webpage <http://www.cnaf.navy.mil>, 2006.

The BRAC recommendations supports both DoD and Navy transformation goals by reducing the number of maintenance levels and streamlining the way maintenance is accomplished with associated significant cost reductions. It supports the NAE's goal of transforming to fewer maintenance levels (i.e., from 3 to 2 levels); and it supports the NAE's strategy of positioning maintenance activities closer to Fleet concentrations when doing so will result in enhanced effectiveness and efficiency, greater agility, and allows

Naval Aviation to achieve the right readiness at the least cost. This transformation to FRCs produces significant reductions in the total cost of maintenance, repair and overhaul plus the associated supply system (packaging, handling, storage and transportation) as well as repairable inventory stocking levels as a result of reduced total repair TATs, reduced transportation, lower spares inventories, less manpower, and more highly utilized infrastructure. It requires integration and collaboration between D-Level Civil Service personnel and Military I-Level Sailors and Marines. (BRAC, 2005a)

a. FRC Expected Savings

The overall projected savings from the 2005 BRAC recommendations are based on reducing overhead and eliminating civilian and military personnel as installations are closed and functions are realigned between installations. Taken individually, the recommendation that the industrial group expects will generate the greatest amount of savings is the establishment of the FRCs, which is estimated to produce net annual recurring savings of \$341 million or 56% of the group's total net annual recurring savings and an estimated 20-year net present value savings of \$4.7 billion or 62% of the group's estimated total net present value savings. This realignment recommendation differs from the other realignments in that it proposes a significant business process reengineering effort to integrate the Navy's non-deployable, intermediate and depot level aircraft maintenance rather than a consolidation or realignment of workload. While the changes proposed would appear to have the potential for significant savings, as explained below, some uncertainty exists about the full magnitude of the savings estimate for this recommendation because most of the group's projected savings are based on efficiency gains that have yet to be validated. For example, the Industrial JCSG found that over 63% of the estimated net annual recurring savings for the FRC recommendation are miscellaneous recurring savings projected to accrue from overhead efficiencies, such as reduced repair time and charges, while 12% of the annual recurring savings is produced from reductions in military personnel and 24% of the savings is derived from reductions in civilian personnel. These efficiencies are expected to be gained from integrating I-Level and D-Level of maintenance and not having to ship as many items to faraway depots for repair. In addition, 34% of the net

implementation savings for this recommendation is derived from other one-time unique savings accrued from one-time reductions in spare parts inventories (GAO-05-785, 2005).

For all FRCs, there is a combined annual facility sustainment savings of \$1.1M; elimination of a total of 529,000 square feet of depot/intermediate maintenance production space and military construction cost avoidances of \$0.2M. This recommendation also includes a military construction cost of \$85.7M. (BRAC, 2005a)

In terms of labor, and assuming no economic recovery, the FRC recommendation could result in a maximum potential reduction of approximately 1,187 jobs from the regionalization of all FRCs, 697 from East Coast FRCs, and 490 jobs between the establishment of FRCs Northwest (NAS Whidbey Island), FRC Southwest (Naval Amphibious Base (NAB) Coronado, NAS North Island), and FRC West (NAS Lemoore) (Coyle, 2005). Between calendar years 2006-2011; 104 to 136 direct and indirect jobs are expected to be reduced in the Bakersfield, California Metropolitan Statistical Area alone. This number represents less than 0.1 percent of the economic area employment in the areas surrounding NAS Lemoore (BRAC, 2005a). On the other hand, 26 civilian jobs will be transferred to the FRC West from the realignment of NAB Coronado. Figure 4 provides an overview of the workload reductions and reallocations of labor for the West Coast FRCs (Coyle, 2005).

How well the FRC concept is implemented will be the key to determining the amount of savings realized. Based on the Industrial JCSG analysis, two types of savings account for the majority of the projected savings from the FRC recommendation. First, one-time savings are projected to accrue from reductions in inventory maintained at several Navy shore locations because item repair cycle time for components is reduced with more D-Level maintenance being performed at or near the Fleet, generally at an intermediate facility. This reduction is accomplished by stationing several D-Level repair personnel at an intermediate facility to assist in repairing an item on site rather than spending time re-packing and shipping the item to a depot for repair. By reducing the TAT for an item—i.e. time spent in transit to and from a depot level repair facility, it is estimated that the average time an item is in the repair pipeline will decrease from 28 hours to 9 hours, with nearly all that time spent on the actual repair. This reduction in TAT will allow for savings since fewer items will need to be kept in the shore based aviation consolidated inventory because items will be getting repaired quicker and returned to the inventory faster.

The second type of savings is recurring overhead savings that are projected to accrue from fewer items being sent to depots for repair. Establishing FRCs will reduce depot repairs, thus reducing per item maintenance costs. When an item is sent to a depot, two charges are applied to the cost to repair the item; a component unit price and a cost recovery rate. If fewer items are sent to a depot, then fewer repair charges are incurred and less overhead costs are incurred. However, since the depots will have fewer items to repair, they will have fewer opportunities to generate revenue to support their working capital fund operations. This situation could create an incentive for the depot to increase its cost recovery rate for items it does repair to make up for reduced revenues. If this were to occur, then the projected savings would not materialize because most of the FRC savings are based on a reduction in the number of items sent to depots and are contingent on the supply system not drastically raising the cost recovery rate.

In an effort to reduce these assumptions, an important step in this transformation effort required DoD to follow through with eliminating management structures and duplicate layers of inventory in the supply system. The S&S JCSG recommendations to realign supply, storage, and distribution management is expected to

further the FRC transformation by eliminating unnecessary redundancies and duplication and by streamlining supply and storage processes, which will reduce costs and help prevent a large increase in the cost recovery rate.

Another assumption is that the workload distribution between the government and contractor establishments will be properly accounted for and recorded. This area bears an enormous amount of risk in properly accounting for depot level work to meet legislatively mandated reporting requirements on the percentage of depot workload performed in government and contractor facilities, absent efforts to ensure adequate differentiation of work completed for I-Level and D-Level maintenance. Similar difficulties occurred in 2001 with the consolidation of I-Level and D-Level work at Pearl Harbor Naval Shipyard, Hawaii. Prior to consolidation, the Navy's determination of I-Level and D-Level maintenance work was based on which facility performed it; the former Pearl Harbor shipyard performed depot work, and the former intermediate maintenance facility performed intermediate work. Because Pacific Fleet and Pearl Harbor officials asserted that all work was considered and classified the same at the consolidated facility, the management and financial systems did not differentiate between depot and intermediate categories of work. As a result, the lines between what was considered intermediate and depot maintenance became blurred, making it harder to report what was I-Level and D-Level maintenance workload.

The remedy proposed during the first few years of implementing the FRCs is for the Navy to continue to operate depot maintenance within the working capital fund (setting up a separate holding account) and perform intermediate maintenance with mission funding (O&M). During this period, D-Level maintenance will be reported as D-Level maintenance and I-Level maintenance will be reported as I-Level maintenance. While this should mitigate the accounting issue in the short-term, it is unclear to what extent longer term measures will be needed to ensure proper reporting of depot work to meet statutory requirements (GAO-05-785, 2005).

Based on the expected efficiencies, benefits, savings, ROI, and known risks, in 2005, DoD issued the final FRC recommendations to the BRAC (BRAC, 2005a).

Listed below are the recommendations that will impact the aviation maintenance functions at the Naval Air Station, Lemoore:

Realign Naval Air Station Lemoore, CA, by disestablishing Aircraft Intermediate Maintenance Department Lemoore and Naval Air Depot North Island Detachment; establishing Fleet Readiness Center West, Naval Air Station Lemoore, CA; and transferring all intermediate and depot maintenance workload and capacity to Fleet Readiness Center West, Naval Air Station Lemoore, CA.

Realign Naval Air Station Fallon, NV, by disestablishing the Aircraft Intermediate Maintenance Department Fallon and the Naval Air Depot North Island Detachment Fallon; establishing Fleet Readiness Center West Site Fallon, Naval Air Station Fallon, NV; and transferring all intermediate and depot maintenance workload and capacity to Fleet Readiness Center West Site Fallon, Naval Air Station Fallon, NV.

Realign Naval Air Warfare Center Weapons Division China Lake, CA, by disestablishing the Aircraft Intermediate Maintenance Department and relocating its maintenance workload and capacity for Aircraft (approximately 3 K DLHs), Aircraft Components (approximately 45 K DLHs), Fabrication & Manufacturing (approximately 6 K DLHs) and Support Equipment (approximately 16 K DLHs) to Fleet Readiness Center West, Naval Air Station Lemoore, CA.

Realign Naval Air Station Joint Reserve Base Fort Worth, TX, by disestablishing the Aircraft Intermediate Maintenance Department, establishing Fleet Readiness Center West Site Fort Worth, Naval Air Station Fort Worth, TX, and transferring all intermediate maintenance workload and capacity to Fleet Readiness Center West Site Fort Worth, Naval Air Station Joint Reserve Base Fort Worth, TX.

The existing intermediate level activity associated with HMX-1 at MCB Quantico, VA, will also be affiliated with FRC East. FRC Southeast will be located on NAS Jacksonville, FL, and will have an affiliated FRC Site at NAS Mayport, FL. FRC West will be located on NAS Lemoore, CA, and will have FRC affiliated sites at NAS JRB Fort Worth, TX, and NAS Fallon, NV. FRC Southwest will be located on Naval Station Coronado, CA, and will have affiliated sites at MCAS Miramar, CA, MCAS Pendleton, CA, MCAS Yuma, AZ, and NAS Point Mugu, CA. FRC Northwest will be located on NAS Whidbey, WA, with no affiliated FRC Sites.

The consolidation of I-Level and D-Level Maintenance functions at NAS Lemoore is estimated to cost DoD a one time implementation charge of \$298.1M. The net of all costs and savings to the Department during the implementation period is a savings of \$1,528.2M annual recurring savings to the Department after implementation the savings will be \$341.2M with a payback expected immediately. The net present value of the costs and savings to the Department over 20 years is a savings of \$4,724.2M (BRAC, 2005a).

c. FRC Implementation

The NAE is well on its way toward implementing the FRC concept to transform aircraft maintenance facilities. In February 2006, the NAE Board of Directors approved the concept of operations developed by NAVAIR's Commander for Aviation Depots to implement BRAC 2005 decisions to establish FRCs. Under this plan the FRCs will report to the Commander, Naval Air Forces (Taormina, 2006).

BRAC's recommendation was essentially a Navy business process reengineering effort to transform the way the Navy conducts aircraft maintenance by integrating existing shore-based (non-deployable) off flight-line intermediate and depot maintenance levels into a single, seamless maintenance level. The FRC construct focuses on the philosophy that some depot level maintenance actions are best accomplished at or near the operational fleet (GAO-05-785, 2005).

The expectation remains that decreased TATs for aircraft maintenance will improve the Navy's ability to maintain the right level of combat-ready aircraft at reduced costs. On 1 August 2006, the Office of the Secretary of Defense approved the FRC business plan (Taormina, 2006). On 10 October 2006, the first FRC (FRC Southwest) was opened at NAB Coronado, (NAS North Island), CA. The planned completion and realignment of all resources for the FRC transition is scheduled for FY09.

The implementation of FRCs is one of the Navy's strategies to support the warfighter and achieve cost-wise readiness in the 21st Century. The establishment of FRCs complements NAE initiatives to achieve cost-wise readiness by making significant changes to the way the Navy and Marine Corps manage repairs across all levels of aviation maintenance. By using Enterprise AIRSpeed tools, the business of Naval

Aviation will migrate to a new level of cost-wise readiness steering toward entitlements based on operational requirements. According to Rear Admiral Hardee, Commander, Fleet Readiness Center, the FRC concept is “[E]mbarking on the most significant and aggressive transformation in Naval aviation maintenance in decades; partnering up our military and civilian maintainers to create these centers creates the kind of “all star” team [N]aval aviation needs for greater efficiency, agility, and velocity of operations.” Private sector partners are bringing additional workload and investment to the FRCs due to its proven track record of being a reliable and cost effective producer (Taormina, 2006.)

d. FRC Contributions Towards Achieving Cost Readiness

FRCs seek to achieve “cost-wiseness” by lowering the cost to the Fleet for repairing expensive AVDLRs; reducing repair TAT and the amount of inventory needed; and by eventually allowing a significant cost-avoidance through careful reductions in the number of spare parts required to maintain the required number of ready for issue (RFI) spares on the shelves.

A fundamental tenet of the FRC concept is the alteration of the traditional repair cycle whenever possible and practical. The FRC enables the BCM interdiction concept when or “if and only if” it makes sense. In some selected cases, the NAE may elect to “repair in place”, rather than ship broken/inoperable components from former I-Levels to “not-on-site” former depots through the supply system. In other cases the NAE may elect to consolidate repair capacities and capabilities at selected places when it makes the best sense. “If and only if” it makes more sense to expeditiously and efficiently do repairs at centralized locations, then that approach may be taken. This will significantly lower “Total Repair Cycle-time” thus driving down costs. In FY03, the Fleet spent approximately \$2.5 billion on aviation repairables. The FRC also achieves substantial “cost-wiseness” and savings through (CNAF, 2006a):

- The BCM interdiction concept. This provides a significant reduction in AVDLR costs to the Fleet, as repairs will be accomplished in-place to the maximum extent possible. This reduces costs associated with sending repairables off-station for repair. D-Level civilian artisans will work side by side with intermediate-level technicians.

- Fixing more components at the new FRCs (including former depots) will result in fewer components being BCM'd to other sites.
- The consolidation and closing of a limited number of active duty and reserve intermediate-levels, but only in those instances where operational fleet basing changes negate the need for resident I-Levels (FRC sites).
- Providing the potential for a substantial cost-avoidance in the shore consolidated allowance list (required spares) inventory in the future. This comes about through needing less buffer inventory as components are repaired faster and cheaper, and through smaller replacement buys for the spares inventory replacements.
- Personnel reductions accomplished through normal attrition and/or re-alignment over a period of several years. If realignment occurs, cost-wiseness is expected to occur by retaining knowledgeable workers and cross-training them into related fields.

Although no comparable data is yet available, the success of the FRCs will ultimately be measured in terms of the impact on total ownership costs. Fleet-driven metrics will be used to monitor the impact of the FRC process at all sites. FRCs are being implemented within Naval Aviation's existing resources to reduce total ownership costs across the life cycle of affected equipment. Since manpower and material are principle cost drivers at every level of maintenance, workload and material requirements will not be shifted from one level to another unless there is clearly a positive effect on total ownership costs.

Annualized availability and cost metrics will be projected and tracked against baseline data. To evaluate the progress and estimate the impact of FRCs, a common metrics framework is currently being developed by subject matter experts. Additionally, in order to provide a definitive basis for decision-making, each FRC site will develop a detailed analysis of the long-term cost/benefits and a realistic assessment of associated risks. Through this documentation process, FRC savings can be assessed and the true impact of the FRCs can be made (CNAF, 2006a).

e. Value-Added Principles

Another strategy is that the consolidation of depot and intermediate levels of maintenance will add value to maintenance activities across the entire NAE by decreasing costs, increasing the knowledge base of maintenance personnel, and improving readiness. This is in line with the NAE CFT concept. In the end, the FRC will eliminate task duplication and repeated troubleshooting, reduce material requirements, reduce the number of work in progress repairables, and improve the feedback loop process.

(1) **FRC Value to People.** On the shop floor, FRCs precisely place Civil Service artisans shoulder-to-shoulder with their Military Sailor and Marine maintainer counterparts to optimize readiness, efficiency, and reliability through a more seamless collaboration of activities. This initiative will result in the following:

- Better training and professional development
- Opportunities to support the next generation of aircraft
- A more satisfying and rewarding place to work

(2) **FRC Value to Cost.** Money is saved by reducing the number of BCM activities moving from intermediate to depot levels. With depot expertise closer to the intermediate level technicians, FRCs will fix it once, fit it right, and fix it on time. The expected outcome includes:

- Reduction of rework
- Less time and money spent on non-value added activities (e.g., shipping, packing, storage, transportation)
- Cost savings help the Navy afford both current and future readiness

(3) **FRC Value to Readiness** Collaboration of depot and intermediate maintenance allows FRCs to transfer knowledge more easily, share resources and quickly identify solutions. This consolidation effort will result in the following:

- Faster TATs
- Less WIP
- Improved reliability
- Increased T/M/S focus (CNAF, 2006b)

4. Virtual Systems Commands (Virtual SYSCOM)

Cost-wise readiness is also achieved through the initiative of a “Virtual SYSCOM”, a system of shared goals and integrated operational concepts: a codified method that enables different Naval commands to work together to identify redundant processes and achieve numerous efficiencies in overall business management. Originating in 2003, leadership from Naval Sea Systems Command (NAVSEA), Naval Air Systems Command (NAVAIR), Space and Naval Warfare Systems Command (SPAWAR), and Naval Supply System Command (NAVSUP) came together to identify redundant processes and achieve numerous efficiencies in overall business management in support of the CNO’s Sea Enterprise and *Sea Power 21* goals and objectives. They are able to better collaborate in order to achieve cost-wise, integrated business and technical practices to better support the Navy. Since 2004, the concept has broadened, as cross-functional SYSCOM teams and “functional communities” were charged with examining their collective effectiveness, reducing their cost of doing business, and integrating their capabilities in a more seamless manner to better serve the warfighter. According to Rear Admiral Stone, Commander, NAVSUP, “the Virtual SYSCOM provides a consistent broad base of cost, technical, and programmatic support for shaping Navy investments that transcends individual commands and programs. The Virtual SYSCOM itself will be a COE as it becomes a clearinghouse for sharing and promoting information on cross-SYSCOM efficiencies and best practices” (Stone, 2005).

5. Public-Privatization Partnerships

A public-private partnership for depot maintenance is an agreement between an organic depot maintenance activity and one or more private industry, or other entities to perform work or utilize facilities and equipment. Program offices, inventory control

points, and materiel/systems/logistics commands may also be parties to such agreements or be designated to act on behalf of organic depot maintenance activities. In general, depot maintenance public-private partnering arrangements include (but are not restricted to) one or more of the following forms (ADUSD (L&MR), 2002):

- Use of public sector facilities, equipment, and employees to perform work or produce goods for the private sector under certain defined circumstances
- Private sector use of public sector equipment and facilities to perform work for the public sector
- Work-sharing agreements, using public and private sector facilities and/or employees

The concept of public-privatization partnerships can help Naval Aviation to be wiser stewards of government funds. The idea for partnering with commercial activities is not one that just suddenly appeared out of Defense transformation discussions; rather it is a strategy that has been around for some time. In fact the Navy once engaged in public and privatization competition in the early 1990s and as such, benefited from this practice until terminating the process in 1994. A specific example of competition at its best occurred during the early 1990s as NADEP Norfolk vied for the F-14 overhaul contract. The competition motivated the NADEP to streamline overhead, improve work processes, reduce labor and material requirements, and implement other cost-saving initiatives in order to submit the lowest possible bids. Process improvement initiatives encouraged NADEP Norfolk to carefully evaluate the maintenance specifications to ensure that they would only perform required repair work and eliminate unnecessary tasks. Each required task was closely evaluated to ensure that the most efficient process was used to accomplish the work. In addition, new staffing requirements were developed from the bottom up to ensure that only the minimum numbers of people with the correct skill levels were assigned to the repair process. As a result of the competition for the F-14 overhaul, the Norfolk NADEP went from a two-shift operation to a one-shift operation and reduced the number of personnel assigned to the program. In this process, Norfolk reduced the F-14 production staff by over 100 people. They also made other changes to increase cost awareness and control. For example, the numbers of cost centers were increased to provide better visibility of production overhead costs and cost center

managers were made responsible for controlling these costs. General overhead costs also were reviewed to eliminate unnecessary expenses.

Another example surrounds the public-private competition for F/A-18 work between NADEP North Island and Air Force. In preparation for this competition, NADEP did a detailed review of the F/A-18 repair operations with a view to reduce costs. One of the changes adopted reduced labor and processing time by moving work crews closer to each aircraft as work progressed instead of physically moving the aircraft to different work stations. Other cost saving changes included establishing central approval authority for recommended repair tasks, having daily progress meetings between the managers and artisans at the site of each aircraft in the plant, and reducing component repair time by only repairing the items needed for safe operation instead of completely overhauling the entire component.

In both cases, the measures adopted by NADEPs in response to competition caused the depots to become more businesslike, with an increased focus on efficiency and bottom-line results. Similarly, public-private competition also provided an increased incentive for private companies to minimize their bids in order to win competed workload. As a result, the officials stated that public-private competition helped to ensure that maintenance work was performed by the activity, public or private, that provided the best value to the government.

Performing a public-private competition was difficult, time-consuming and resource intensive. As a result, few competitions were completed before DoD's termination of the program in 1994 (GAO/NSIAD-96-30, 1996). Though the practice was terminated, Naval Aviation learned valuable lessons of becoming an efficient organization, and had experienced the first glimpse into the notion of public-privatization and the movement toward "cost-wiseness".

So it is with irony that on 30 January 2002, The Deputy Under Secretary of Defense for Logistics and Material Readiness (DUSD (L&MR)) issued a policy letter to the Military Secretaries outlining DoD's policy to use public-private partnerships for depot maintenance. This outsourcing tactic closely parallels the initiative that was terminated in 1994. Specifically, the letter stated, "[T]he Military Departments shall

shape partnership agreements to support DoD and Defense-related workloads. Partnerships can improve the utilization of DoD facilities, equipment, and personnel. Partnerships can bring a wide variety of additional benefits to the parties involved in the agreement, and also foster improved support to the warfighter” (ADUSD (L&MR), 2002).

To recognize the core competencies of depot maintenance activities, the policy letter mandates that each Military Department designate its depot maintenance activities as Centers of Industrial and Technical Excellence (CITE). (SECNAV, 2002). As such, depot maintenance public-private partnerships are formed around these identified core competencies. In a July 2002 memorandum to NAVAIR, NAVSEA, SPAWAR, and the Marine Corps Systems Command, the Secretary of the Navy formally designated Navy and Marine Corps depot maintenance facilities as CITE (SECNAV, 2002).

6. Performance Based Logistics (PBL)

Logistics support has traditionally provided the supply, repair, and maintenance of items necessary for the proper operation of a system using an organizational, intermediate, and depot maintenance philosophy. The DoD is promoting the use of Performance Based Logistics (PBL) as a cost effective alternative to traditional logistics support.

PBL is the purchase of support as an integrated, affordable, performance package designed to optimize system readiness and meet performance goals for a weapons system through long-term support arrangements with clear lines of authority and responsibility (DAU, 2006). PBL can help program managers (PM) optimize performance and cost objectives through the strategic implementation of varying degrees of Government-Industry partnerships.

PBL is DoD’s preferred approach for product support implementation (DAU, 2005). Product support is defined as a package of logistics support functions necessary to maintain the readiness and operational capability of a system or subsystem. PBL utilizes a performance based acquisition strategy that is developed, refined, and implemented

during the systems acquisition process for new programs or as a result of an assessment of performance and support alternatives for fielded systems. PBL is a means of procuring performance by capitalizing on integrated logistics chains and public/private partnerships. The cornerstone of PBL is the purchase of weapons system sustainment as an affordable, integrated (DAU, 2006a).

The essence of PBL is buying performance outcomes [weapons system availability rather than input measures], the individual parts, and repair actions. Simply put, performance based strategies buy outcomes, not products or services (DAU, 2005). This is accomplished through a business relationship that is structured to meet the warfighter's requirements.

DoD policy states that “PMs shall develop and implement PBL strategies that optimize total system availability while minimizing cost and logistics footprint... sustainment strategies shall include the best use of public and private sector capabilities through Government/industry partnering initiatives, in accordance with statutory requirements” (DAU, 2006a).

One of the most significant aspects of PBL is the concept of a negotiated agreement between the major stakeholders (e.g. the PM, the operational force provider—the unit, and the support provider(s)—contractor or DLA) that formally documents the performance and support expectations, and commensurate resources, to achieve the desired PBL outcomes. DoD Instruction 5000.2 states, “[t]he PM shall work with the users to document performance and support requirements/strategies in performance agreements specifying objective outcomes, measures, resource commitments, and stakeholder responsibilities” (DAU, 2006a). On the other hand, Military Services shall document sustainment procedures that ensure integrated combat support.

PBL support strategies integrate responsibility for system support in the Product Support Integrator (PSI) who manages all sources of support. A PSI is an entity performing as a formally bound agent charged with integrating all sources of support, public and private, defined within the scope of the PBL to achieve the documented outcomes. A PSI can be: The system's OEM or prime contractor, a DoD Component organization or command, or a third-party logistics company. Source of support

decisions for PBL do not favor either organic (government) or commercial providers. The decision is based upon a best-value determination, evidenced through a business case analysis (BCA), of the provider's product support capability to meet set performance objectives. The BCA assesses the best mix of public and private capabilities, infrastructure, skills base, past performance, and proven capabilities to meet set performance objectives. This major shift, from the traditional approach of transaction-based purchasing to product support, emphasizes what level of support program manager teams buy, not who they buy from. Instead of buying set levels of spares, repairs, tools, and data, the new focus is on buying a predetermined level of availability to meet the warfighter's objectives. This is a fundamental and significant change, in that it transitions the responsibility and corresponding risk for making support decisions to the PSI (DAU, 2006a).

a. Metrics

A key component of any PBL implementation is the establishment of metrics. Since the purpose of PBL is 'buying performance,' what constitutes performance must be defined in a manner in which the achievement of performance can be tracked, measured, and assessed. The identification of top-level metrics achieves this objective. The PM works with the end user/warfighter to establish system performance needs and then works with the product support providers to fulfill those needs through documentation of the requirements (including appropriate metrics) in Performance Based Agreements (PBAs). An effective PBL implementation depends on metrics that accurately reflect the user's needs and can be an effective measure of the support provider's performance.

Linking metrics to existing warfighter measures of performance and reporting systems is preferable. Many existing logistics and financial metrics can be related to top-level warfighter performance outcomes (DAU, 2005). Although actual PBL strategies may delineate metrics at levels lower than the warfighter top-level measures (e.g., system availability), the initial identification of performance outcomes should be consistent with the five key top-level metric areas outlined in the USD (AT&L) memorandum of 16 August 2004 titled: "Performance Based Logistics: Purchasing Using Performance Based Criteria." These PBL top-level metric objectives are as follows:

- Operational Availability
- Operational Reliability
- Cost per Unit Usage
- Logistics Footprint
- Logistics Response Time

Each of the performance outcomes are defined in detail in Table 3, a sample listing of performance requirements and metrics which NAVAIR uses for tailoring and inclusion into PBL agreements.

In his 2004 memorandum, the Secretary also indicated the preferred PBL contracting approach is the use of long-term contracts with incentives tied to performance. Specific highlights of the policy included:

- Award term contracts should be used where possible to incentivize optimal industry support.
- Incentives should be tied to metrics tailored by the Military Departments to reflect their specific definitions and reporting processes.
- Award and incentive contracts shall include tailored cost reporting to enable appropriate contract management and to facilitate future cost estimating and price analysis.
- PBL contracts must include a definition of metrics and should be constructed to provide industry with a firm period of performance.
- Wherever possible, PBL contracts should be fixed price (e.g., fixed price per operating or system operating hour) (USD (AT&L), 2004). Fixed-price contracts are generally appropriate for services that can be defined objectively and for which the risk of performance is manageable (GAO-02-1049, 2002).
- Lack of data on systems performance or maintenance costs, or other pricing risk factors may necessitate cost-type contracts for some early stage PBLs.
- Full access to DoD demand data will be incorporated into all PBL contracts.

PERFORMANCE OUTCOMES	METRICS/CONSIDERATIONS
<ul style="list-style-type: none"> Operational Availability (Ao): The percent of time that a system is available for a mission or the ability to sustain operations tempo. 	<ul style="list-style-type: none"> (Ao)- (Under Full CLS Only) Readiness Mission Capable Rates Sortie Generation Rate Turn- Around-Times Surge Requirements Reduced Down Time
<ul style="list-style-type: none"> Operational Reliability: The measure of a system in meeting mission success objectives (percent of objectives met, by system). Depending on the system, a mission objective could be a sortie, tour, launch, destination reached, or other service- and system-specific metric. 	<ul style="list-style-type: none"> Sortie Mission Completions Time On Wing Mean Time Between Failures (MTBF) MTBF Improvement No Fault Found Reduction Elimination
<ul style="list-style-type: none"> Cost Per Unit Usage: The total operating cost divided by the appropriate unit of measurement for a given system. Depending on the system, the measurement unit could be flight hour, steaming hour, launch, mile driven, or other service- and system-specific metric. 	<ul style="list-style-type: none"> Cost Per Flight Hour Annual FFP Cost (prorated by units) Obsolescence Management Attrition Replacement Sustaining Engineering ECP Costs Total Ownership Cost (TOC)
<ul style="list-style-type: none"> Logistics Footprint: The Government/ contractor size or presence of deployed logistics support required to deploy, sustain, and move a system. Measurable elements include inventory/equipment, personnel, facilities, transportation assets, and real estate. 	<ul style="list-style-type: none"> Maintenance Planning Reliability improvement Reduced Cannibalizations Support Equipment/Training/Publications Inventory Needs Staffing Levels
<ul style="list-style-type: none"> Logistics Response Time: The period of time from logistics demand signal sent to satisfaction of that logistics demand. 'Logistics demand' refers to systems, components, or resources (including labor) required for system logistics support. 	<ul style="list-style-type: none"> Parts Availability First Pass Effectiveness Maintainability P,H,S&T Mean Logistics Down Time Supply Chain Management

Table 3. NAVAIR Performance Outcomes and Metrics.

Source: NAVAIRINST 4081.2A. Policy Guidance for Performance Based Logistics Candidates.

- PBL contracts should be competitively sourced wherever possible and should make maximum use of small and disadvantaged sources.
- PBL contractors should be encouraged to use small and disadvantaged businesses as subcontractors, and may be incentivized to do so through PBL contractual incentives tied to small and disadvantaged business subcontracting goals.

b. Federal Acquisition Regulation (FAR) Requirements

The Federal Acquisition Regulation (FAR), part 37.6 defines performance-based contracting as structuring all aspects of an acquisition around the purpose of the work to be performed with the contract requirements set forth in clear, specific, and objective terms with measurable outcomes as opposed to either the manner by which the work is to be performed or broad and imprecise statements of work.

In prescribing policies and procedures for use of performance-based contracting methods, the FAR states that such methods are intended to ensure that required performance quality levels are achieved and that total payment is related to the degree that services performed meet contract standards (GAO-02-1049, 2002). The FAR requires performance-based contracts to:

- Describe the requirements in terms of results required rather than the methods of performance of the work
- Use measurable performance standards (i.e. terms of quality, timeliness, quantity, etc.) and quality assurance surveillance plans
- Specify procedures for reductions of fee or for reductions to the price of a fixed-price contract when services are not performed or do not meet contract requirements
- Include performance incentives where appropriate

The FAR further addresses elements of performance-based contracting; specifically statements of work, quality assurance, and contract type. The FAR specifies that in preparing statements of work, agencies shall, to the maximum extent practicable, (GAO-02-1049, 2002):

- Describe the work in terms of “what” is to be the required output rather than either “how” the work is to be accomplished or the number of hours to be provided
- Enable assessment of work performance against measurable performance standards
- Rely on the use of measurable performance standards and financial incentives to encourage competitors to develop and institute innovative and cost-effective methods of performing the work, and
- Avoid combining requirements into a single acquisition that is too broad for the agency or a prospective contractor to manage effectively.

c. NAVAIR PBL Program

DoD Directive 5000.1 and 5000.2 directs acquisition managers to consider and use performance-based strategies for acquiring and sustaining products and services whenever feasible, and further directs program managers to develop and implement PBL strategies that optimize total system availability while minimizing cost and logistics footprint. PBL realization seeks to achieve the following:

- ❖ Procure an outcome (stated as a level of performance) rather than specific products or services
- ❖ Incentivize the provider by linking payment to actual performance. Incentives may include firm fixed type contracts, extended contract periods, and monetary incentives. It also provides program stability, which allows providers to make long term commitments resulting in cost savings to both the contractor and the Navy
- ❖ Implement realistic, easily understood performance metrics. Performance metrics for PBLs will be stated in terms of readiness, availability, reliability, etc.
- ❖ Tell the provider what the Government wants instead of how to do it. However, the Government reserves the right to direct engineering changes, when necessary.

NAVAIR will generally issue a Statement of Objectives (SOO) for the PBL that provides top-level program objectives and allows providers maximum flexibility in tailoring and proposing an innovative and cost effective Statement of Work (SOW) to satisfy the SOO requirements

- ❖ Empower the provider with the authorization and responsibility to control those elements required to successfully support the program. The following are examples of the functions that may be delegated to the provider:
 - Obsolescence Management
 - Public Private Partnerships
 - Requirements Determination and Acquisition
 - Packaging, Handling, Storage and Transportation (PHST)
 - Warehousing
 - Engineering and Technical Services
 - Technology Insertion
 - Configuration Management
 - Retrograde Management
 - Foreign Military Sales (FMS) Support (if applicable)
- ❖ Reduce the logistics footprint
- ❖ Have minimal or no impact to the Fleet. This means the PBL is essentially transparent, posing no additional tasking on Fleet maintainers and no additional impact to any other product support elements
- ❖ Mitigate long term risk by ensuring exit provisions are included in the contract/agreement to facilitate the re-establishment of organic or commercial support capability, if needed (NAVAIR, 2004)

(1) **PBL Candidate Analysis.** In keeping with the above regulations, goals, and expectations, NAVAIR evaluates potential PBL candidates by completing a PBL Candidate Analysis, also referred to as a Cost Benefit Analysis. The

function of PBL Candidate Analysis is to identify the requirements and compare the costs associated with two different product support strategies (PBL and traditional). It includes the additional tasks of assessing core impact on requirements and recommending an acquisition strategy.

PBL Candidate Analysis progress is assessed in conjunction with formal program reviews. This assessment is used to determine the probability of a PBL strategy meeting established performance requirements while achieving cost goals. Results are used to adjust the PBL strategy (including performance and cost goals) to ensure maximum value is achieved.

The PBL Candidate Analysis is composed of a Core Analysis and Determination and two interdependent analyses; the Operational Analysis and Results Recommendation, and the Business Analysis and Results Recommendation. The successful conduct of the last two analyses is essential in determining the most cost-effective support (PBL or traditional) and as justification for the final approval of the PBL candidate. The PBL BCA process is outlined in NAVAIRINST 4081.2A, but for brevity is described here. Figure 5 is a process flow chart of the NAVAIR PBL process.

The Core Analysis is in response to statutory requirements contained in Title 10 U.S.C. Section 2464 and the DoD Core Methodology. The analysis ascertains those capabilities and depot-level workload that must be maintained in public facilities to fulfill JCS strategic and contingency plans. Ideally, the preliminary Core Analysis is conducted prior to Milestone B to serve as an advisory to PMs as well as influence early depot maintenance planning efforts. A final Core Analysis is completed when definitive information regarding all depot-level repairables becomes available.

The Core Analysis results are sent to the program office, NAVICP, and the candidate organic depot. The results may also be provided to other recipients as needed to determine, support, and execute the PBL candidate's support strategy. If the workload is required to sustain core capability, a PBL incorporating a partnering arrangement between the provider and an organic depot must be considered. If the workload is not required to sustain core capability, a "best value" provider is sought.

The Operational Analysis is a detailed examination of the performance requirements and it identifies or develops the metric(s) needed to determine if the performance requirements are being met. Table 3 provides a listing of potential metrics used in the BCA process. The Operational Analysis must provide an estimate of the impact to current product support elements (for existing systems and subsystem components) or a projected estimate of the impact to product support elements (for developing systems/subsystems/components) to support the BCA process in the Business Analysis. It also provides a basis for assessing potential (positive and negative) impacts to other existing systems, subsystems, components, and existing product support elements.

The results of the Operational Analysis provide performance requirements and metrics that may be used in the PBA. The PBA is an agreement between the warfighter and the PM that establishes Key Performance Parameters for support of a Weapon System. The PBA is typically a short document in the form of a Memorandum of Agreement (MOA) or Memorandum of Understanding (MOU). This System Level PBA agreement defines outcomes for the overall PBL support strategy and contains measures of success to meet the warfighters' needs. Any subsequent agreements for subsystems and components should establish metrics that will contribute to the performance outcomes defined within the system level PBA. Over the life of the program, the performance measures may change or evolve depending on the changing requirements of the program.

The Business Analysis consists of the BCA and the PBL acquisition strategy. The BCA is the decision making tool used to estimate the costs of different product support strategies. It normally compares a baseline support strategy against one or more proposed PBL support strategies to determine the relevant cost of supporting a system, subsystem, or component at the levels identified in the Operational Analysis and PBA. A BCA is required for all PBL candidates. The BCA should be conducted using the latest, most accurate information available from the Operational Analysis and at a level commensurate with the program acquisition category (NAVAIR, 2004).

The Acquisition Strategy should be developed in accordance with the latest DoD acquisition guidance and after the product support requirements and metrics have been determined. The acquisition strategy should address:

- PBL Determination
- Budgeting and Funding
- FMS
- Procurement Issues
- Contract Issues
- Length of PBL Commitment
- Incentives for Industry
- Metrics

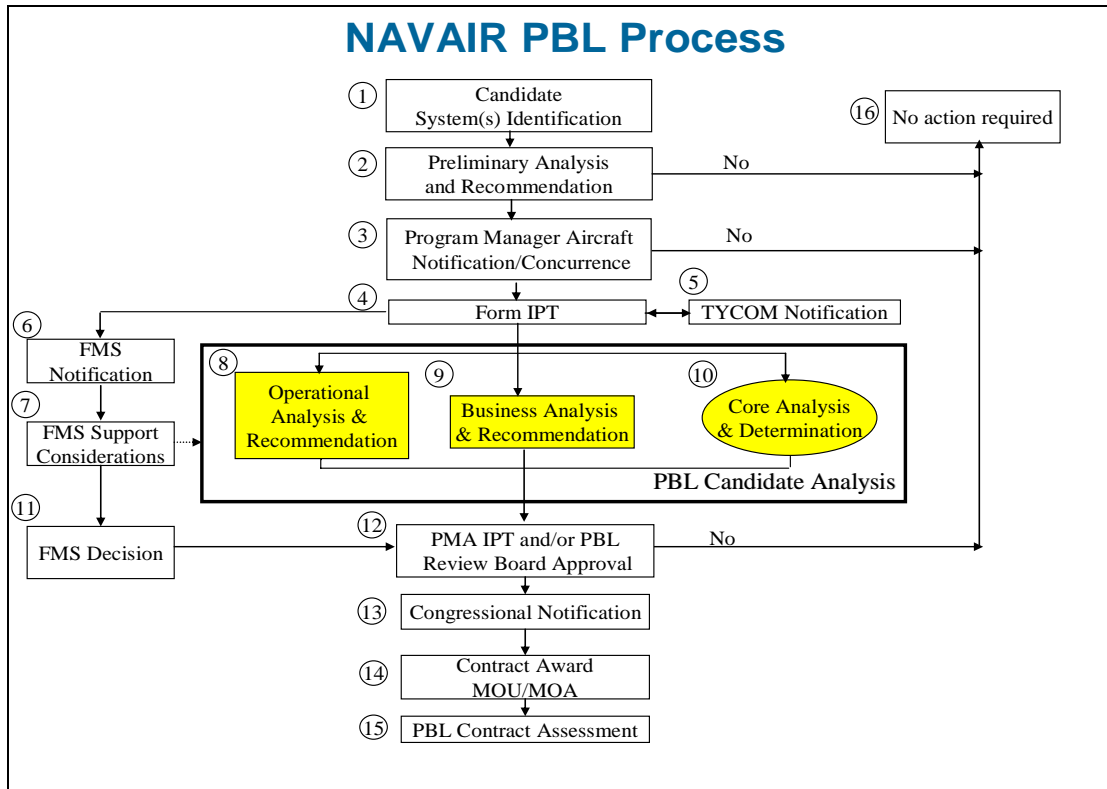


Figure 5. NAVAIR PBL Process.

Source: NAVAIRINST 4081.2A. Policy Guidance for Performance Based Logistics Candidates

d. Statutory Considerations

There are numerous federal laws that apply to the outsourcing of depot maintenance workload. Other sections of Title 10, U.S.C. that may affect the depot-level workloads associated with the PBL candidate include:

- Section 2466, 50/50 Rule: Allows no more than 50% of the funds made available in a given fiscal year to a Military Department for depot-level maintenance and repair to be used to contract for performance by non-governmental personnel. Note: This statute is applied at the Service Component level (e.g., 50% of Navy-wide funds).
- Section 2469, > \$3 Million Rule: (1) Requires public-private competition to move depot-level workload from an organic depot (over \$3M annually) to the private

sector; and (2) Requires merit-based procedures to move depot-level workload from one organic depot (over \$3M. annually) to another organic depot.

- Section 2474, CITE - Public Private Partnerships: Designates depot-level activities as CITE. Enables CITES to enter into public-private partnerships for the performance of work related to the core competencies of the center. Also, allows private industry use of DoD facilities or equipment of the CITE that is not being fully utilized.
- Section 2563, Articles and Services of Industrial Facilities - Sales to Persons Outside the DoD: This section authorizes the Services to sell articles and services outside DoD that are not readily available (time, quality, quantity) from a U.S. commercial source (NAVAIR, 2004).

e. PBL Achievement of Cost-Wiseness

Since their implementation, PBL contracts have proved to steadily decrease maintenance costs. The achievement of *availability metrics* exceeded budgeted levels and below budgeted costs. Design clean up/improvement, reliability improvements, repair TAT reductions, work process improvements, extension of high time limits, build specifications improvements, multi-year parts buys, flow down contracts with subs, better parts quality, and reduced demand have contributed to lower costs. Specific examples of cost savings and efficiency are provided below:

- ❖ F404 PBL (F/A-18A-D), a Four and 1/2 Year Firm-Fixed Price Contract achieved:
 - 100% Total Backorder Reduction Contract-to-Date
 - Availability 95% (Historical, 43%)
 - TAT Reduced by 25%; Backlog Reduced 50%
- ❖ Navy's First Public/Private Partnership, "Corporate Contract" awarded June 2000 to Honeywell to provide support for Auxiliary Power Units (APU) used on the C-2, F/A-18, S-3, and P-3 Aircraft

<u>Asset Management</u>	<u>Pre TLS</u>	<u>FY-05</u>	<u>Target</u>
Back Orders	123	0	0
Availability	65%	91%	90%
Logistics Response Time	35 days	6.6 days	5 days
G Condition	232	0	0

Additional Benefits:

- \$50M+ savings/cost avoidances to Navy
- 79 configuration changes implemented to address reliability (18) and correct drawing errors, improve maintainability, or address obsolescence (61)
- 110 APUs (\$14M) removed from inventory due to improved asset management
- Depot TAT reduced from 98 to 67 days (25%)
- Commercial Best Practices (LSS) standardized at NADEPs and Honeywell
- Corporate contract enabled adding KC-130 APU, P-3 engine driven compressor and F/A-18 main engine fuel control and allows Joint Services efforts
- All F404 MFC backorders eliminated November 2005; 12 F404-402 conversions completed in 2005

❖ Savings using PBL versus Traditional Repair

PBL Vs. Traditional Repair (Notional)

PBL

- Parts Cost: \$300,000
- Labor & Admin Costs: \$34,000
- Total Cost: \$334,000
- Average Life: 2,000 hours
- **Cost per hour: \$167**



Traditional Repair

- Parts Cost: \$120,000
- Labor & Admin Costs: \$34,000
- Total Cost: \$154,000
- Average Life: 375 hours
- **Cost per hour: \$411**



Figure 6. Comparison of PBL and Traditional Repair.

Source: Performance Based Logistics brief presented to 15th TACOM LCMC/Industry Logistics Symposium on 15 March 2006.

IV. RADAR CENTER OF EXCELLENCE (COE)

A. FUNCTIONAL PROCESS DESCRIPTION

The AIMD NAS Lemoore provides aviation support for the Navy's F/A-18 Super Hornet. It also has the responsibility of managing a proof of concept pilot program called the Radar Center of Excellence (COE). The Radar COE was established in May 2006 as an AN/APG-65/73 radar maintenance work center performing maintenance and calibration for the entire CNAF (D. Stephens, personal communication, 13 September 2006, 2006). The AN/APG-65/73 radar is a critical component of the F/A-18 Super Hornet, providing fire control capabilities during air-to-air and air-to-ground missions. It is also the most expensive and most common degrader on the F/A-18 (D. Stephens, personal communication, 13 September 2006). The Radar COE will "find smart ways to fix radars" by integrating former depot-level and intermediate-level maintenance activity elements into a seamless continuum of maintenance, logistics, and engineering support (D. Stephens, personal communication, 13 September 2006). Additionally, in order to provide a definitive basis for future decision-making, each the Radar COE develops detailed analysis of the long-term benefits and realistic assessment of associated risks. NAS Lemoore's Radar COE is also the future site for FRC West, and so the comprehensive FRC implementation plan that is being developed by the NAE will encompass the COE's analysis of its financial management, total force management, data analysis, maintenance information systems/IT, logistics, engineering, supply chain management, maintenance processes, and quality assurance. This evaluation will be critical in adequately planning and establishing FRC West in a manner which encompasses a fully-integrated business approach (NAVRIIP, 2006).

The Radar COE framework is not completely new as it is very similar to Centers of Industrial and Technical Excellence (CITEs) (SECNAV, 2005). Title 10 U.S.C. Section 2474 declares a CITE a consolidated depot maintenance activity entering into public-private partnerships to perform work related to the specific core competencies of the designee (SECNAV, 2005). Section 2474 specifically discusses three criteria establishing designation and three criteria establishing public-private partnership.

Designation:

(1) The Secretary concerned, or the Secretary of Defense in the case of a Defense Agency, shall designate each depot-level activity of the military departments and the Defense Agencies (other than facilities approved for closure or major realignment under the Defense Base Closure and Realignment Act of 1990 (part A of title XXIX of Public Law 101–510; 10 U.S.C. 2687 note)) as a Center of Industrial and Technical Excellence in the recognized core competencies of the designee.

(2) The Secretary of Defense shall establish a policy to encourage the Secretary of each military department and the head of each Defense Agency to reengineer industrial processes and adopt best-business practices at their Centers of Industrial and Technical Excellence in connection with their core competency requirements, so as to serve as recognized leaders in their core competencies throughout the Department of Defense and in the national technology and industrial base (as defined in section 2500 (1) of this title).

(3) The Secretary of a military department may conduct a pilot program, consistent with applicable requirements of law, to test any practices referred to in paragraph (2) that the Secretary determines could improve the efficiency and effectiveness of operations at Centers of Industrial and Technical Excellence, improve the support provided by the Centers for the armed forces user of the services of the Centers, and enhance readiness by reducing the time that it takes to repair equipment.

Public-Private Partnerships:

(1) To achieve one or more objectives set forth in paragraph (2), the Secretary designating a Center of Industrial and Technical Excellence under subsection (a) may authorize and encourage the head of the Center to enter into public-private cooperative arrangements (in this section referred to as a “public-private partnership”) to provide for any of the following:

(a) For employees of the Center, private industry, or other entities outside the Department of Defense to perform (under contract, subcontract, or otherwise) work related to the core competencies of the Center, including any depot-level maintenance and repair work that involves one or more core competencies of the Center.

(b) For private industry or other entities outside the Department of Defense to use, for any period of time determined to be consistent with the needs of the Department of Defense, any facilities or equipment of the Center that are not fully utilized for a military department’s own production or maintenance requirements.

(2) The objectives for exercising the authority provided in paragraph (1) are as follows:

(a) To maximize the utilization of the capacity of a Center of Industrial and Technical Excellence.

(b) To reduce or eliminate the cost of ownership of a Center by the Department of Defense in such areas of responsibility as operations and maintenance and environmental remediation.

(c) To reduce the cost of products of the Department of Defense produced or maintained at a Center.

(d) To leverage private sector investment in—

(i) such efforts as plant and equipment recapitalization for a Center; and

(ii) the promotion of the undertaking of commercial business ventures at a Center.

(e) To foster cooperation between the armed forces and private industry.

(3) If the Secretary concerned, or the Secretary of Defense in the case of a Defense Agency, authorizes the use of public-private partnerships under this subsection, the Secretary shall submit to Congress a report evaluating the need for loan guarantee authority, similar to the ARMS Initiative loan guarantee program under section 4555 of this title, to facilitate the establishment of public-private partnerships and the achievement of the objectives set forth in paragraph (2).

The three criteria establishing designation and three criteria establishing public-private partnership under Section 2474 are applicable to the COE since the Radar COE will be a recognized core competency for the Fleet as it will perform maintenance and calibration on the AN/APG-65/73 radar. NAS Lemoore has not received official designation from CNAF as the Radar COE but once it does, it will serve as a recognized leader in their core competency throughout the Navy (D. Stephens, personal communication, 13 September 2006). The COE is a pilot program testing the efficiency and effectiveness of operations that enhance readiness by reducing the time that it takes to repair radars. Finally, the COE has entered into a public-private partnership to have

work performed that relates to its core competencies. Raytheon Company, the manufacture of the AN/APG-65/73 radar, has an AN/APG-65/73 radar technician working at NAS Lemoore full-time. Although the COE and CITE carry different labels, the end result is the same; consolidate depot-level maintenance activities to produce the most cost-effective use of tax dollars (McCain, 2001).

1. Working Model of *AIRSpeed* in the Naval Aviation Enterprise (NAE)

The Radar COE has integrated Theory of Constraints (TOC) and Lean Six Sigma methodologies in order to apply them across the entire enterprise (A. Ioannidis, personal communication, 4 August 2006). Lean Six Sigma concentrates on the removal of multiple elements, inputs, sub-processes, and anything that does not add value to the production process thereby reducing the Cycle Time for the product or service provided to the intended user. TOC focuses on the idea that all organizations have at least one constraint and that any improvements on non-constraints may not yield as significant ROI as working on the constraint itself. It is based on market demand (pull) in which physical inventory (buffer levels) are formed and related processes at maintenance activities are based on actual demand (pull) measured as the time to reliably replenish (TRR). TRR illustrates how much time elapses to replenish a product, resource, or material.

To effectively and efficiently prepare ready for tasking (RFT) aircraft, *AIRSpeed* focuses on the proper levels of shop replaceable assemblies (SRA) and consumable parts, in order to facilitate the decrease in the acquisition for new more expensive weapon replaceable assemblies (WRA) (Nieto, 1994). WRA is the standard term given to all replaceable components of avionics equipment installed in an aircraft and the SRA includes all portions of the aircraft. A WRA is composed entirely of SRAs but does not include cable assemblies, mounts, fuse boxes, or circuit breakers. A WRA failure is defined as a deteriorated performance level that would cause a required function of the assembly to be unavailable if the WRA were installed in the next higher assembly (i.e., an avionics weapon system platform). SRA failure is defined as a performance level that would cause a failure of the WRA if it were installed in its next higher assembly (the applicable WRA).

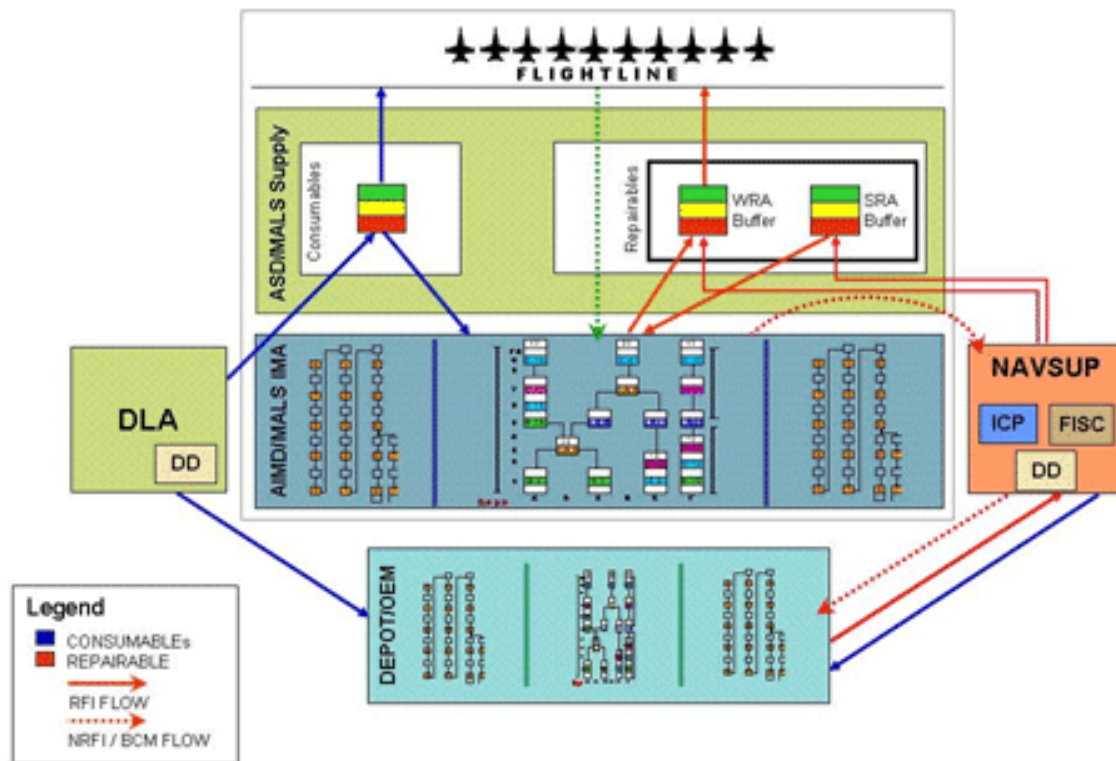


Figure 7. Process Flow Diagram for Enterprise AIRSpeed.
Source: Nieto, Enterprise AIRSpeed 1994.

The AIRSpeed design identifies those areas where Lean Six Sigma can reduce the constraint on RFT aircraft, i.e. TRR. It is essential to maintain WRA and supporting SRA inventory levels that are capable of sustaining aircraft readiness. End user demand patterns and TRR levels impact these inventories, and so the process flow is monitored to maintain a balance between TRR and inventory allowance levels. A reduction in TRR is not [always] cost effective because it causes WRA and SRA inventories to decline more often, which hinders the ability to meet demand (Nieto, 1994).

Figure 7 demonstrates this design within the supply and maintenance process flow for AIRSpeed Enterprises. Within the figure, the Flightline is the O-level which is where demand starts. The green dotted arrow is the flow of failed SRAs and WRAs that will be inducted to I-level maintenance. Not-ready-for-issue (NRFI) components are the same as failed SRAs and WRAs. AIMD/MALS IMA (Aircraft Intermediate Maintenance Depot/Marine Aviation Logistics Squadron Intermediate Maintenance Activity) is the I-

level. When repair capability does not exist at the I-level, NRFIs flow to NAVSUP (Naval Supply Systems Command) as depicted by the red dotted arrow. From NAVSUP, the failed SRAs and WRAs flow to the D-level for repair. (Agripino, et al., 2002)

NAVSUP manages a number of programs that have direct impact on the combat readiness of the Fleet including inventory control points (ICP), Fleet and Industrial Supply Centers (FISC), and Defense Depots (DD). All materials used by the Navy are considered items of supply and will be managed by an ICP. Excluded are those items assigned to a single agency or military service inventory manager for supporting retail stock or end-use requirements of the military services. FISCs provide a variety of logistics support services to fleet, shore activities, and overseas bases. DDs are regional storage points for Defense Logistics Agency (DLA) material. Issue of material from a DD is directed by the responsible Defense Supply Center (DSC) and is based on requisitions received and processed by the DSC.

After inducting failed SRAs and WRAs to the I-level, the O-level generates supply requisitions for ready-for-issue (RFI) components. O-level requisitions are filled from the inventory of material maintained in the SRA and WRA stock buffers. NAVSUP inventory managers monitor and manage the issue and demand of material in these buffers as displayed by the solid blue and red arrows in Figure 7. Inventory control responsibilities include determining: material requirements, replenishment actions, quantity of material to be on hand and on order to sustain current operations, financial requirements initiating procurement and disposal material, disposition of material, the repositioning of material, and the requirement for original equipment manufacturer (OEM) components. Unneeded materials and worn-out components are turned in to the Defense Reutilization and Marketing Office (DRMO). In managing end-user material, FISCs are responsible for determining inventory levels, procuring, receiving, storing, issuing, shipping, or delivering material to the customer.

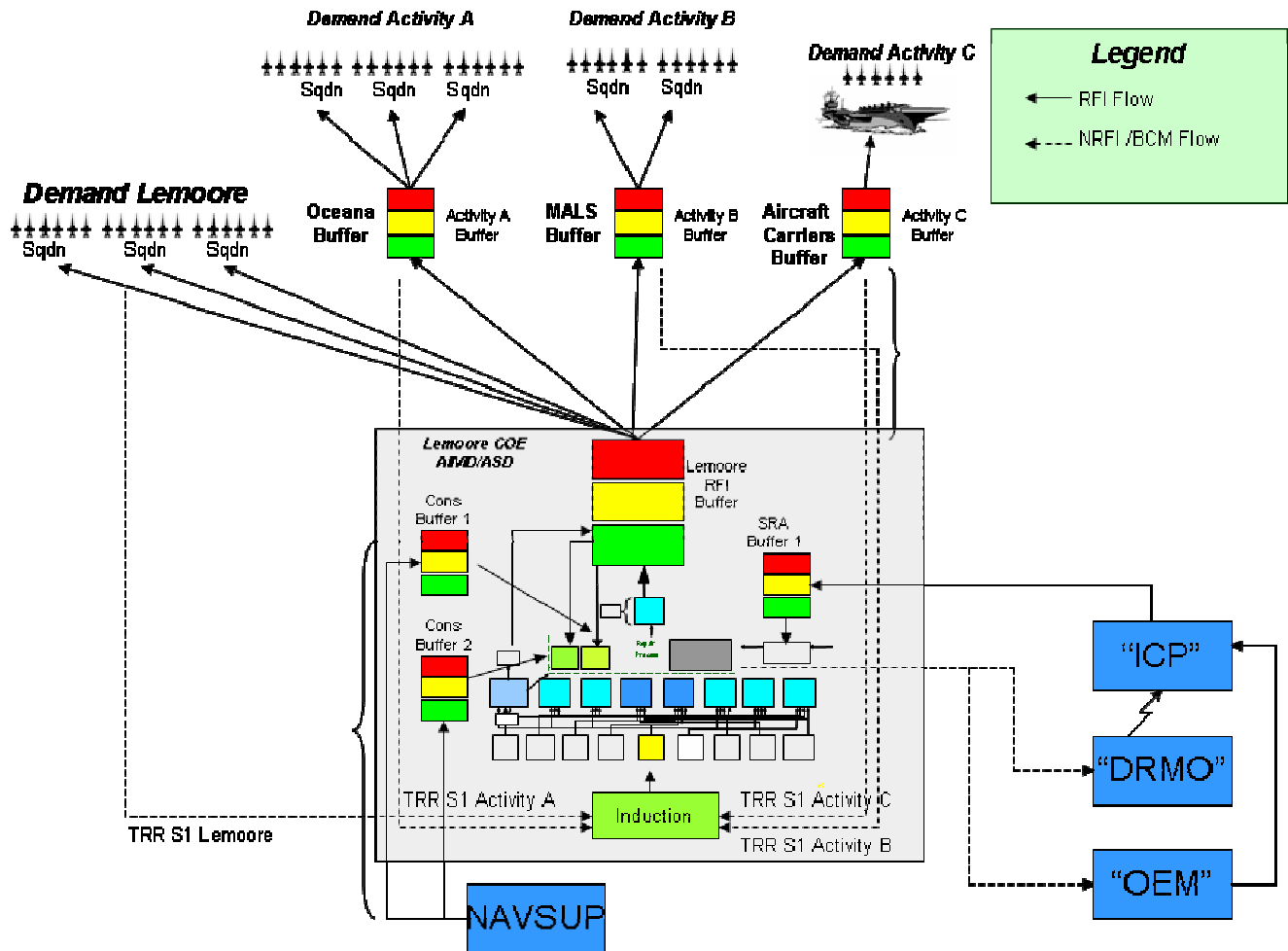


Figure 8. Process Flow Diagram for Radar COE.
Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

To achieve a truly Lean approach, some organizational structures within the current [Enterprise AIRSpeed model] must be integrated (Agripino, et al., 2002). Figure 8, the process flow diagram for the Radar COE, illustrates this with the consolidation and integration of the following sustainment functions: in-service engineering, logistics support, intermediate/depot maintenance, operational support, and supply support. This organizational framework facilitates close coordination between operational support and lifecycle support networks. Within Figure 8, Demand Activities A, B, and C represent the O-level which is where demand starts. The dotted arrows flowing from the Demand Activities illustrate failed radars that will be inducted into maintenance at the COE. The Radar COE is an integrated I-level/D-level maintenance organization performing lifecycle that includes servicing, inspecting, testing, adjustment, alignment, removal,

replacement, reinstallation, troubleshooting, calibration, repair, modification, and overhaul of AN/APG-65/73 radar systems and components. At the point of induction, AN/APG-65/73 radar systems and components are sent to specific work centers responsible for a particular component. When repair capability does not exist at the COE, NRFI's flow to DRMO or to the OEM as depicted by the dotted arrow. The OEM will refurbish, reuse, and incorporate the component into a new product with its own brand name (Stephens, 2006a).

Squadron and Carrier replacement requisitions are filled from the inventory of material maintained in the Demand Activity buffers. In Figure 8, each Demand Activity's TRR S1 is initiated once an AN/APG-65/73 radar NRFI component is received by the Radar COE for maintenance. Once repairs are complete, RFI components are shipped to appropriate Demand Activity Buffers to ensure continuing end user requirements are met. Consumable and repairable components are replenished from NAVSUP and used to repair the NRFI component. The [Radar COE's] integrated design should result in significant cost savings and improved cycle time performance, outperforming a conventional [D-level organization], because it integrates a "Lean" framework for sustaining operational support, inventory control, and process improvement functions (Agripino, et al., 2002). TRR, a key metric for Leanness, should be reduced as lead times and TATs are decreased to an absolute minimum to obtain low cost, high quality, and on-time material availability.

According to the *AIRSpeed* Officer at AIMD NAS Lemoore, the integrated model for the Radar COE has generated greater efficiencies but is not without its challenges (D. Stephens, personal communication, 13 September 2006). The Radar COE is a pilot program still maturing as a viable *AIRSpeed* with concerns that begin with the occasional non-availability of material, consumables, and repairables. The current allowancing policy currently dictates inventory levels to support the I-Level demand (D. Stephens, personal communication, 13 September 2006). With the integration of I-Level and D-Level maintenance occurring at the Radar COE, this policy will not represent the quantity that is required to sustain operations. Greater than normal demands and inadequate replenishment stocks can negatively impact the COE's ability to meet established TRRs. Inventory management requires control of and agreement between stock and stock

records, accurate control procedures, evaluating usage, and anticipating requirements. The COE must ensure that ordering times, fill rates, maintenance TATs, and other metrics realistically portray the impact and interaction of their supply, transportation, maintenance, and procurement systems. Determining the scope and quantity of consumables and repairables to be procured and stocked must be constantly evaluated and adjusted to sustain a Lean operation.

Another challenge is ensuring that the Radar COE design comprises core capabilities with sufficient support equipment, resources, and sufficient surge capacity to meet the desired TRRs (D. Stephens, personal communication, 13 September 2006). Core capability, at a minimum, includes skilled artisans, equipment, and facilities needed to accomplish maintenance at the Radar COE. To comply with the statutory requirements set forth in Title 10 U.S.C. Sections 2464 and 2474, the [COE] determines its core capability requirements and the workloads needed to sustain that capability (OSD, 2004). The Radar COE's infrastructure and capability shape will be sized to support Naval readiness when organizational agility, flexibility, and proximity to the operating forces are crucial to accomplish the mission (OSD, 2004).

Other barriers include determining who owns what and who pays for what as assets are intermingled and integrated (D. Stephens, personal communication, 13 September 2006). For example, there are currently two active systems to order consumables and SRAs at the COE; Naval Aviation Logistics Command Management Information System (NALCOMIS) and the Monthly Maintenance Plan (MMP). NALCOMIS is an automated information management system that provides the COE with the information to aid in the day-to-day management of the maintenance effort. The system provides detailed procedures to enter, collect, process, store, review, and report maintenance and flight data that are required to manage the maintenance organization (OPNAVINST 4790.2J, 2005). The MMP provides an outlook of upcoming scheduled maintenance, which includes inspections, transfers, and receipts of aircraft. By developing a strategy for scheduled maintenance, managers can determine the capability for unscheduled work in relation to material, manpower, and maintenance process

resources in advance of the actual demand. As the Radar COE continues its implementation of the new model, these issues will be reviewed and addressed in future refinements of the organization.

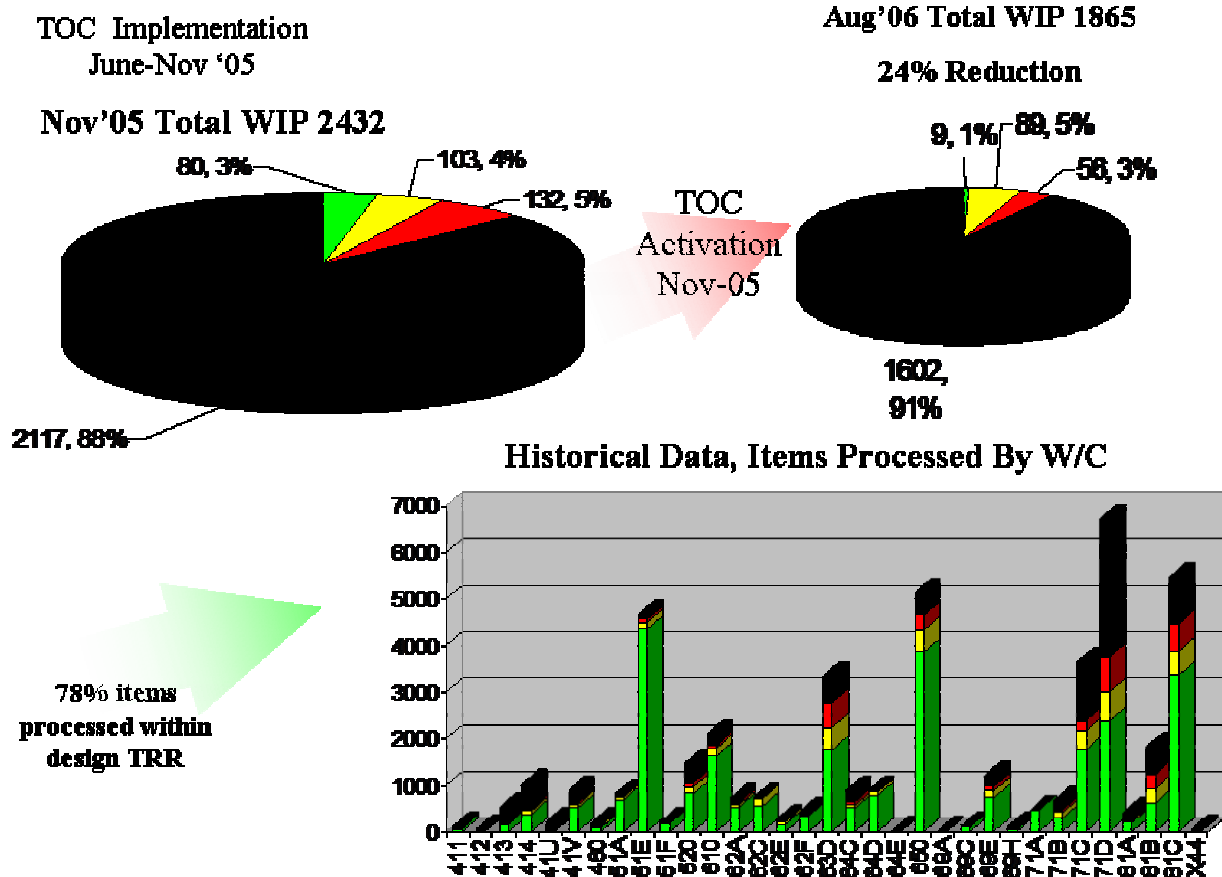
B. PERFORMANCE IMPACT AND METRICS

The Radar COE represents a key element in AIMD Lemoore's transformation to FRC West; ultimately having the capability to sustain RFT aircraft for the Fleet. The COE concept organizes activities to optimize repair procedures. This concentrates radar repair expertise in fewer places and builds the foundation in business process improvements envisioned for the FRC. Decreased cycle times and decreased TRRs are the projected metric as duplicate and useless procedures are eliminated. Additionally, creating a "culture of cost consciousness integration" and interoperability will improve "the feedback loop between all levels of maintenance" (Fathke, 2005). After the application of TOC principles and Lean Six Sigma at the COE, radar maintenance became a more controlled and stable process. Furthermore, TRR trends and irregularities were identifiable, explainable, and traceable (Stephens, 2006b).

TRR metric reporting provides a means for the COE to analyze and chart their TRR performance data to determine "their health in operating in a time domain" (AIRSpeed, 2005). Figure 9 compares TRR trends at AIMD Lemoore before and after TOC implementation. The pie charts and histogram within Figure 9 use black, red, yellow, and green color coding which is characteristic of AIRSpeed reports. Each indicator has a threshold for each color rating. TRR indicators become yellow when a NRFI is expected to be close to or over that threshold and red when it is definitely going to go over and action needs to be taken. TRR indicators become black when a NRFI has gone over the TRR threshold. When any work center within the Depot is first turned on, there may be components in the queue that are in various TRR statuses (AIRSpeed, 2005). The general scheduling rule is First-In-First-Out. NRFIs are acted on in this sequence until repaired or worked as much as possible and put to the side if not workable, e.g. awaiting parts, awaiting mechanic, etc. In that situation, the next NRFI on the schedule goes to the work center. Enterprise AIRSpeed procedures dictate risk management of the impact on other items in process when adjusting workload priorities

to act on NRFIs that have become black. A black item that will be a quick fix should be a low risk to act on before a red or yellow item. Management of work-in-process (WIP) items occurs by working the workable red, yellow and then green.

TRR Trend



the integration of I-Level and D-Level maintenance. Maintenance managers are constantly analyzing processes and implementing actions to establish stability in the COE design. For example, to mitigate items with black TRRs, managers established two full shifts working four days a week for ten hours a day. There were also work sections working Friday and Saturday in order to increase work center utilization by 32 hours a week.

RADAR Busting TRR (Pre-TOC Activation)

- **Weekend/Holiday = 15**
- **Excessive M3 Time = 209**
- **Excessive AWP Time = 81**
- **Excessive/Late AWP Iteration = 26**
- **Excessive M5 Time = 8**
- **Lack of Test Equipment = 6**
- **Excessive S1 Time = 1**
- **Excessive M8 Time = 5**

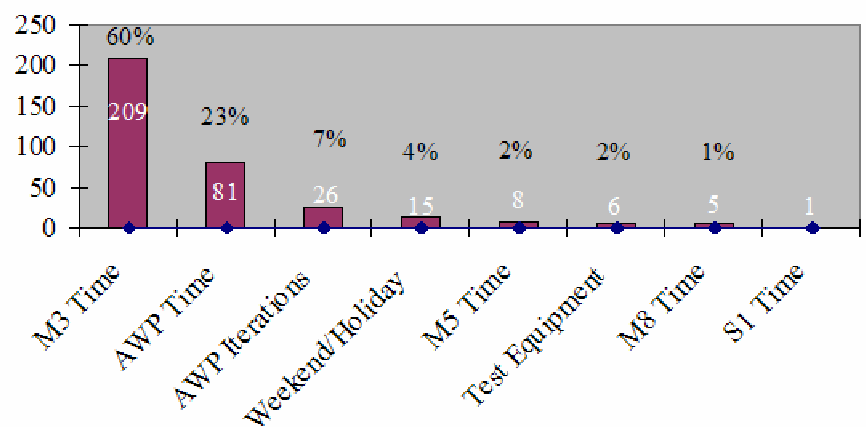


Figure 10. Histogram of AN/APG-65/73 Radar TRR Days Before Applying Theory of Constraints.
Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

Figure 10 displays 351 AN/APG-65/73 radars awaiting maintenance from November 2004 to June 2005 prior to the implementation of TOC at AIMD Lemoore. The radar TRR indicators were in the black, having gone over the TRR threshold. The radars were categorized according to NALCOMIS job status code. The following is an explanation of each NALCOMIS Job Status Code according to the *Naval Aviation Maintenance Program (NAMP), Vol. III, COMNAVAIRFORINST 4790.2, 2005*:

- ❖ M3 Time – AWM (Awaiting Maintenance) Backlog: Any workload in excess of work center capability
- ❖ AWP (Awaiting Parts) Time – The time during which the component was not being worked on while awaiting repair parts not available locally
- ❖ AWP (Awaiting Parts) Iterations – Repairs cannot be completed because only some repair parts have been received while awaiting the remaining repair parts not available locally
- ❖ Weekend/Holiday – Any maintenance requirement that exists beyond normal working hours
- ❖ M5 Time - AWM (Awaiting Maintenance) Other: Any performance of maintenance precluded by weather, operational conditions, general drill, training, shipboard/shore station imposed restrictions, etc.
- ❖ Test Equipment – Lack of adequate test equipment to performance maintenance
- ❖ M8 Time - AWM (Awaiting Maintenance) Awaiting Other Shops: No further maintenance can be performed due to shops or maintenance actions
- ❖ S1 Time - AWM (Awaiting Maintenance) in Depot: Awaiting the return of a component in process in the Depot. (COMNAVAIRFORINST 4790.2 Vol. III, 2005)

RADAR Busting TRR (Since TOC Activation)

- Weekend/Holiday = 42
- Excessive M3 Time = 127
- Excessive AWP Time = 87
- Excessive/Late AWP Iteration = 32
- Excessive M5 Time = 13
- Lack of Test Equipment = 19
- Excessive S1 Time = 0
- Excessive M8 Time = 3

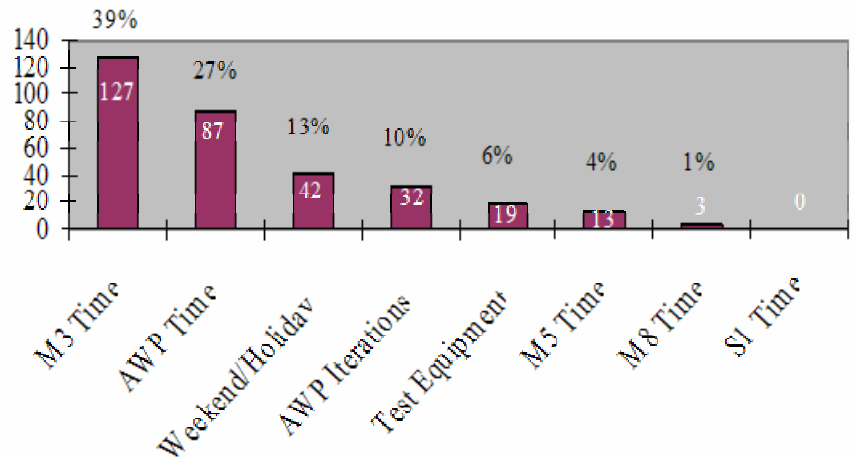


Figure 11. Histogram of AN/APG-65/73 Radar TRR Days After Applying Theory of Constraints.

Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

Figure 11 displays 323 AN/APG-65/73 radars awaiting maintenance from June 2005 to July 2006 since the implementation of TOC at the Radar COE. Over this 13 month period, there were 28 less radars in the black. This was an 8% reduction in comparison to the amount illustrated over 8 months in Figure 10. Since TOC implementation, radars with M3 job status codes decreased by 39%. Radars with AWP job status codes went up by 6, which was a 7% increase. Radars with AWP Iterations job status codes also went up by 6, which was a 23% increase. Radars with Weekend/Holiday job status codes went up by 27, which was a 180% increase. Radars with M5 job status codes went up by 5, which was a 63% increase. Radars with Test Equipment job status codes went up by 13, which was an increase of 216%. Radars with a job status code of M8 decreased by 40%, which was a reduction of 2. Radars with job status codes S1 went from 1 to 0.

RADAR Busting TRR (Current WIP-Aug 2006)

- Weekend/Holiday = 4
- Excessive M3 Time = 13
- Excessive AWP Time = 20
- Excessive/Late AWP Iteration = 3
- Excessive M5 Time = 3
- Lack of Test Equipment = 1
- Excessive S1 Time = 0
- Excessive M8 Time = 1

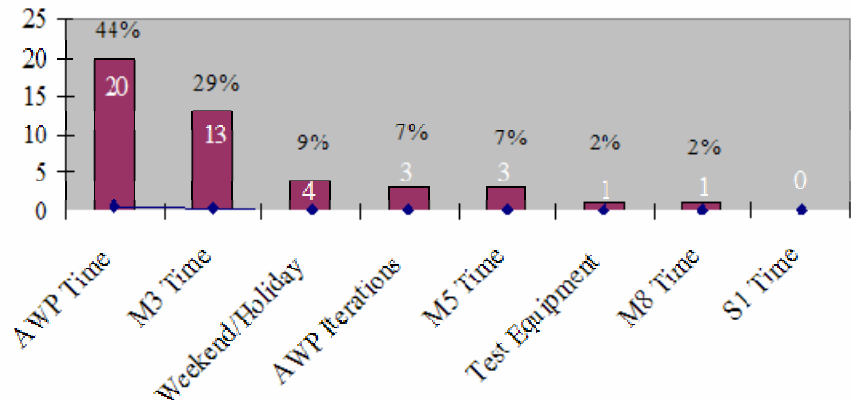


Figure 12. Histogram of Current AN/APG-65/73 Radar TRR Days.
Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

Comparison of Radar Busting TRR Before and After TOC Activation

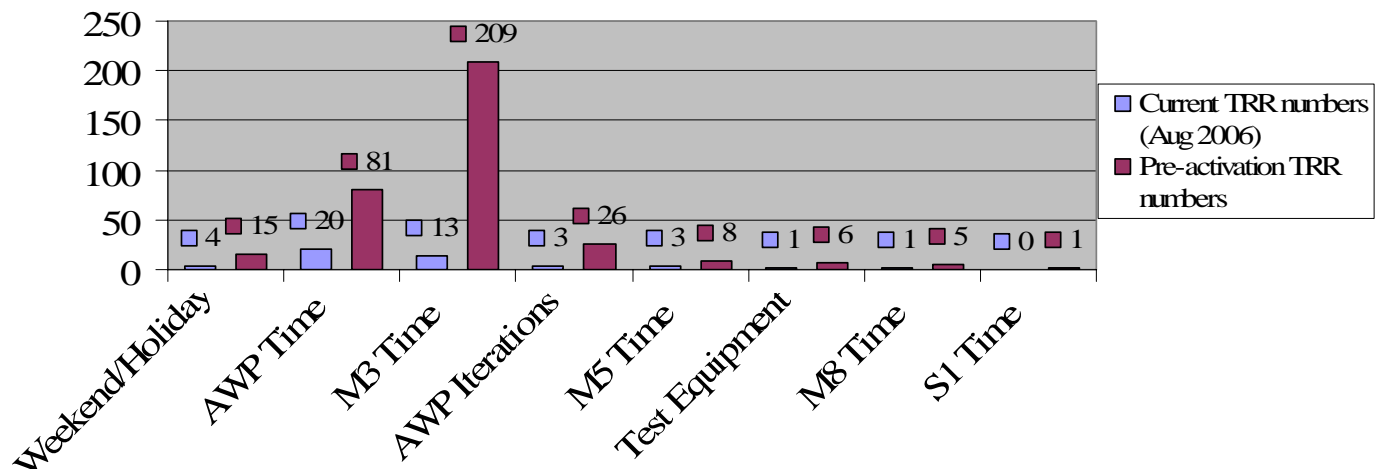
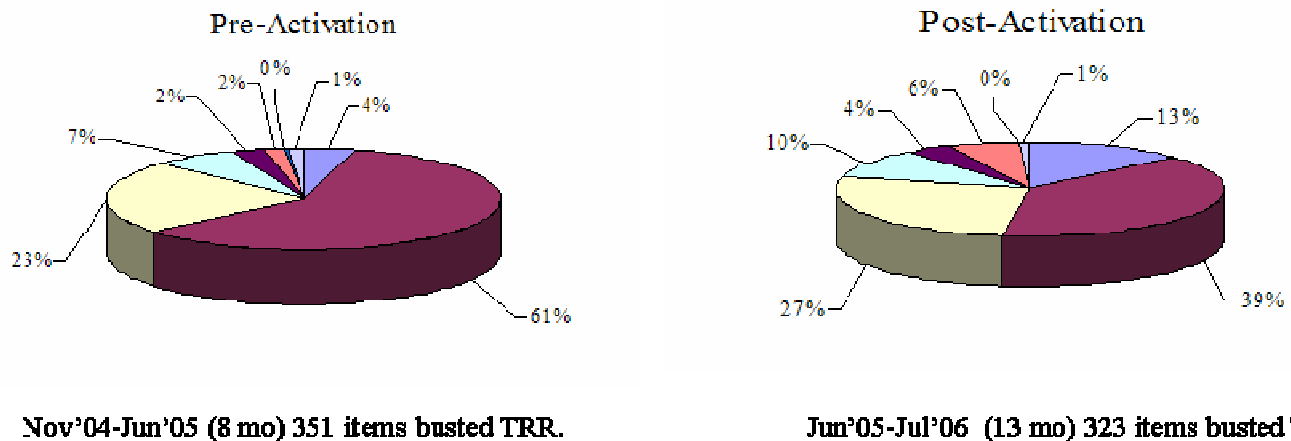


Figure 13. Histogram of Current and Pre-Activation AN/APG-65/73 Radar TRR Days.

Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

The Radar COE has experienced improvements by applying TOC and Lean Six Sigma principles as evidenced by the reductions captured in Figure 9, Figure 10, and Figure 11. Further review of Figure 9, Figure 10, Figure 11, and Figure 14 shows that radars with job status AWP and M3 (AWM (Awaiting Maintenance) Backlog) are the highest categories in spite of any overall reductions that are realized. Figure 13 provides a comparison of AN/APG-65/73 radars having gone over the TRR threshold before and after the implementation of TOC at AIMD Lemoore. While the Radar COE continues to transform based on cost-wise readiness and the Lean paradigm, it still is affected by the “inefficiency and complexity of the current military sustainment model” (Agripino, et al., 2002). The supply system that is necessary to replenish the RFI stock inventory and consumables required to support the end user is a “sustainment system [with] uncoupled processes, fragmented organizational structures, and uncoordinated distribution channels” (Agripino, et al., 2002). This unresponsive support system hinders the evolving maintenance, repair, and overhaul framework until it begins to mirror the COE’s Lean approach.

RADAR Busting TRR Pie Chart Comparison



■ Weekend/Holiday ■ M3 Time ■ AWP Time ■ AWP Iterations ■ M5 Time ■ Test Equipment ■ S1 Time ■ M8 Time

Figure 14. Pie Charts Comparing AN/APG-65/73 Radar TRR Days Before and After Applying Theory of Constraints.

Source: Stephens, D. NAS Lemoore COE Supply Chain Radar Brief, 2006.

Note: The pre-activation pie chart covers 8 months while the post-activation pie chart covers 13 months. During TOC pre-activation, more radars broke the TRR threshold in less time. During TOC post-activation, less radars broke the TRR threshold over a longer time period.

C. OPERATIONAL COST SAVINGS AND SUCCESSES

How does the Radar COE know if it is Lean? Appropriately chosen metrics are the performance characteristics that are used to assess whether [this] enterprise is Lean (Agripino, et al., 2002). Some examples include reducing cycle time, lowering costs, minimizing waste, improving quality, and reducing time to reliably replenish (TRR). These demonstrated metrics used to measure improvements have also been applied at AIMD Lemoore. Great strides have been made in creating the culture of cost-wise readiness at the COE using Enterprise AIRSpeed principles as the key enabler to their success. By reducing TRRs and decreasing inventories, [the COE has been] able to reduce the number of personnel and assets required to support [itself] (Kemna, 2005). The COE is supporting the Fleet Response Plan (FRP) by providing RFT aircraft. The

entire NAE has benefited from reduced inventories, lower operating expenses, and manpower reductions. Decreased cycle times mean improved logistics and maintenance response.

At the end of 2005, *AIRSpeed* efficiencies resulted in \$123 million made available for other O&M requirements (Massenburg, 2005). AIMD sailors are working an average of 8 hours instead of 12 hours. Re-enlistment rates for Enlisted Sailors have risen from 47% to over 76%. Radar shop repair processing time has been reduced from 14 days to 2 days. The work center that manages aircraft armament equipment improved its issue/receipt process which resulted in the removal of 6 sailors that were then placed into repair work centers.

Beyond Capability of Maintenance (BCM) interdiction is a critical expectation of the COE and FRC model. BCM is a term used by maintenance depots when repair is not authorized at that level, when an activity is not capable of accomplishing the repair because of a lack of equipment, facilities, technical skills, technical data, or parts, or when shop backlog precludes repair within time limits specified by existing directives (COMNAVAIRFORINST 4790.2 Vol. III, 2005). BCM interdiction provides a significant reduction in Aviation Depot Level Repairable (AVDLR) costs to the Fleet, since repairs will be accomplished in-place to the maximum extent possible. This reduces costs associated with sending repairables off-station for repair and aligns the financial accountability to the consumer of the resource (Fathke, 2005). Although the AIMD at NAS Lemoore continues to process BCM assets, they continue to mitigate many more with the Radar COE project as it matures as an FRC with the integration of D-Level artisans (D. Stephens, personal communication, 13 September 2006).

The Radar COE exists as another *AIRSpeed* pilot program that has met the challenge of creating dynamic cultural change at all levels of the enterprise. Furthermore, the COE represents the beneficial attributes that all aviation maintenance and supply organizations will attain once the principles of *AIRSpeed* become a core competency within the entire NAE. No longer can Naval Aviation afford to operate in the same manner, therefore better practices [have been] incorporated in order to achieve cost-wise readiness, [affordability, and flexibility] in future aircraft acquisitions and re-

capitalization of our aging Fleet (Nieto, 1994). The Navy has seen greater value in consolidating their separate activities and using best practices and continuous improvement with a strong emphasis on supporting the end user with ready for tasking aircraft.

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V. CONCLUSIONS

A. INTRODUCTION

The goal of this research project was to identify the funding formulation and the current cost trends of maintaining an aging fleet of aircraft and to provide an analysis of current and future maintenance programs designed to build efficiency and reduce total ownership costs. Specifically, the study examined the Radar Center of Excellence at NAS Lemoore as it relates to cost-wise readiness and Enterprise *AIRSpeed*. The methodology of the study involved a description of the funding elements of aviation maintenance and review of the current processes and future initiatives associated with Aircraft Operations Maintenance. We also reviewed resource and performance data used by aircraft maintenance policy officers and *AIRSpeed* officers to determine resource requirements essential in defining maintenance capabilities. Additionally, the study highlighted critical analysis taken from Joint Chiefs of Staff (JCS) studies, Base Realignment and Closure (BRAC) reports, General Accounting Office (GAO) reports, public laws pertaining to DoD maintenance, Naval Aviation Maintenance Subsystem Reporting (NAMSRS) Plus maintenance and material data, and FY03 and FY04 Execution of the Operations Plan-20 (OP-20), in order to (1) understand the ability of gaining depots to absorb additional work loads; and (2) understand legislative actions mandating specific criteria relating to maintenance initiatives.

B. ANSWERS TO PRIMARY RESEARCH QUESTION

1. To what degree of effectiveness is the Navy presently able to meet its aircraft maintenance requirements with its current resources?

The complete FRC implementation across the Navy coupled with an analysis of the FRC's financial management, total force management, maintenance information systems/information technology, logistics, engineering, supply chain management, and maintenance processes will be necessary to determine if the *AIRSpeed* design has reaped any significant improvements to the efficiency, effectiveness, and cost effects of the program. However, substantial improvements are evident in the ability of Commander,

Naval Air Forces (CNAF) aviation maintenance managers in implementing, validating, and sustaining Enterprise *AIRSpeed* programs. The Navy's composite approach that operates under a triad of existing methodologies: Theory of Constraints (TOC), Lean production and Six Sigma, demonstrates the emergence of improved processes, improved tracking and forecasting maintenance tools, and more accurate inputs used in the construction of budget, maintenance, and procurement plans. These developments then translate into an improvement in the overall execution of aviation maintenance i.e. cost-wise readiness (tied to the demands of combatant commanders); improved time on wing (better equipment with better maintenance so that it stays on the aircraft longer); greater speed/reduced cycle time (aircraft and components spending less time in maintenance); improved reliability (quality); and reduced total costs. Chapter III, paragraph B.1.d and Chapter IV, section C highlight many of the qualitative and quantitative successes of aviation maintenance transformation initiatives. In these instances, by focusing on four key metrics: inventory, cycle time, quality, and total cost; the *AIRSpeed* model has improved all aspects of maintenance supply responsiveness – for the benefit of the warfighter.

Answers to the secondary research questions will provide specific outcomes resulting from the aircraft maintenance model enhancements and subsequent process changes.

C. ANSWERS TO SECONDARY RESEARCH QUESTIONS

1. What specific changes, if any, have been made to aircraft maintenance process models to improve efficiency and effectiveness of current programs?

Chapter III of the study highlights the specific changes to aircraft maintenance process models. Chapter IV of the study provides specific details of the Enterprise *AIRSpeed* model process flow. Current and forecasted inefficiencies, inept maintenance operations, constrained processes, and inadequate funds resulting from pouring dollars into achieving capabilities today at the expense of future capabilities were the key reasons for change within the Navy. The following is a summary of those changes.

AIRSpeed: *AIRSpeed* is a unique efficiency model that has created an integrated culture of self-sustaining CPI aligned toward delivering mission requirements at reduced resource cost for the NAE. There are three *AIRSpeed* programs: Depot, Enterprise and NAVAIR; each employing industry-proven best business processes and methodologies to reduce cycle time, improve productivity, and focus on the total aviation solution within all levels of supply and maintenance.

Fleet Readiness Centers (FRC): The FRC concept integrates former depot-level and intermediate-level maintenance activity elements into a seamless continuum of maintenance, logistics, and engineering support. This strategy positions maintenance activities closer to Fleet concentrations when doing so will result in enhanced effectiveness and efficiency, greater agility, allowing Naval Aviation to achieve the right readiness at the least cost. Furthermore, the transformation to FRCs will see more integration and collaboration between depot level Civil Service personnel and Military intermediate level Sailors and Marines, thus achieving “cost-wiseness” by lowering the costs for repairing expensive AVDLRs; reducing repair turn around time; and by eventually allowing a significant cost-avoidance through careful reductions in the number of spare parts required to maintain the required number of RFI spares on the shelves.

Virtual SYSCOM: This system has supported the paradigm shift to working across functions thereby creating opportunities for sharing information and integrating operational concepts. The Virtual SYSCOM serves as a Navy enabler in identifying redundant processes and achieving enterprise management efficiencies.

Public-Privatization Partnerships: Public-private partnerships related to the core competencies of the Navy enterprise reduce or eliminate the cost of ownership, maximize the utilization of depot capacity, and reduce the cost of products. Furthermore, these partnerships have fostered greater collaboration and cooperation between the Navy and the private industry.

Performance Based Logistics (PBL): PBL contracts have proved to steadily decrease maintenance costs through performance based strategies, and buying outcomes, not products or services. By purchasing long-term support as an integrated, affordable, performance package designed to optimize system readiness and performance goals, the

best-value determination and assessment of public and private capabilities, infrastructure, skills base, past performance, and proven capabilities can be made to meet performance objectives.

2. If changes have been made, have they produced any significant and measurable improvements in readiness and cost?

As previously mentioned, the most significant outcome of using the various aircraft maintenance process models is reflected in direct cost savings, reduced cycle time, improved processes, improved tracking and forecasting maintenance tools, and more accurate inputs used in the construction of budget, maintenance, and procurement plans. Chapter III, paragraph B.1.d and Chapter IV, section C highlight such improvements as North Island's F/A-18 turnaround time reduction from 192 days to 132, the average Work-In-Progress (WIP) reduction of 37% and *AIRSpeed* efficiencies resulting in \$123 million made available for other O&M requirements. An accurate assessment of any recognized benefits will require the complete implementation of FRCs across the Navy and the execution of budget cycles thereafter to ascertain what if any program efficiencies eventually materialize.

3. How will future budgeting affect aircraft maintenance processes?

The Navy is ensuring wise and informed decisions are made before each dollar is spent, and that each expense serves an intended purpose. Employing cost-wise techniques in incorporating process improvement initiatives in maintenance operations and workforce development will have to be continuous and dynamic with the potential future of constrained budgeting challenges.

D. CONCLUSIONS

Reduced budgets, constrained maintenance processes, fragmented organizational structures, and the prospect of having inadequate future aircraft capabilities have forced the Navy to re-evaluate how to manage the total life cycle of its fleet of aircraft. Cost-wise initiatives, such as *AIRSpeed*, have presented viable solutions to uncoordinated systems, non-value added processes, and budget problems; focusing on improving the entire Navy enterprise. The Navy has maximized the fundamental principles of being

Lean production, Six Sigma, and TOC, through the integration of the processes, organizational restructuring, overhauling maintenance, supply, and inventory functions to insure that a total systems engineering approach is effectively and efficiently used. The *AIRSpeed* model provides the necessary framework to develop this total systems approach to Lean sustainment of ready for tasking aircraft. The incorporation of aircraft maintenance process changes, reflect compliance with the Fleet Response Plan (FRP), Navy transformation vision, and provide enhanced capabilities in supporting an aging fleet of aircraft that are increasingly expensive to maintain.

E. RECOMMENDATIONS FOR FURTHER STUDY

1. Since the Radar COE at NAS Lemoore is still maturing and will also be the future site for FRC West, a study of the effectiveness of the COE once complete and used for a few years could provide beneficial information to improve the comprehensive FRC implementation plan.

2. Perform an analysis of the FRC implementation across the Navy once complete and (a) determine the amount of recurring overhead savings and inventory reduction savings realized and (b) determine if workload distribution between the government and contractor establishments are properly accounted for and recorded. The lack of sufficient quantitative data precludes the drawing of any definitive conclusions from the current study.

3. Perform an analysis of all the active aviation maintenance PBL contracts the Navy has in place in comparison to targeted use baselines and methodologies to (a) determine cost effectiveness of the contracts, (b) determine the level of complexity in assessing costs and performance of contracts, (c) determine if the contracts are actually reducing the aviation logistics footprint and adequately monitoring life cycle costs.

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